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Two scientists are on a mission to fight global heating where its effects are most vivid: Norway's Arctic archipelago of Svalbard

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**ANN BABE**

Babe writes about a mental-health crisis worsened by Covid: the isolation of hikikomori – people who can shun human contact for years. “The joke goes that hikikomori were already prepared for lockdown, but they’re as lonely as the rest of us.”

**MARGARET TAYLOR**

Taylor profiles Quickest Sheriff, an MD who quit to start a medical mental-health resource. “Female physicians are 400 per cent more likely to take their own lives compared to male counterparts. Sheriff’s forum helps create a vital support network.”

**DELLE CHAN**

Chan explores Israel’s alt-meat startups, and how Kosher concerns might unlock success. “Israel has a huge veggie food scene, so it’s a good fit for plant-based innovation, while Kosher certification for the cell-based lab-meat products will help them go global.”

PORTRAITS OF ISOLATION

Tim Franco photographs the hikikomori of South Korea – people who have withdrawn from society and human contact for so long that many have forgotten skills such as how to interact with other humans. There is help, and but for some on the path to rehabilitation, like Kim Ho-seon (*above*), the Covid-19 lockdowns risked their progress. “Hikikomori struggle to socialise, and I realised that taking direction while being photographed might be a challenge,” says Franco. “I quickly discovered that screens were a certain source of comfort, so I had my subjects look at theirs, and then used their computers’ brightness as a kind of atmospheric lighting.”

Creating WIRED

**NORTHERN LIGHTS**

Photographer Catherine Hyland spent time in the Arctic town of Longyearbyen in Svalbard for perhaps our most northerly feature ever. “I don’t think I’ve ever been anywhere that I didn’t see a glimpse of Sun for such long periods of time,” she says. “It starts to make the days feel very repetitive, as the light doesn’t really change from morning to night. It was one of the most surreal places I have ever seen people choose to live.”



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As I write, at the tail end of 2020, the relentless Covid news cycle has taken another turn – the encouraging roll-out of the vaccines in the UK (if accomplished without the logistical failures that marred the sourcing of PPE and the dismal roll-out of test and trace) is tempered by the arrival of a highly-transmissible variant of the disease.

It's likely to be a long, hard winter, but there is now hope that – in high-income countries at least – the second half of 2021 should mean a return to something like normality, even if many public health experts anticipate some restrictions to be in place until 2022. Scientific research and the co-operation between biotech companies backed by government guarantees has driven vaccine research at unprecedented speed, while also proving the effectiveness of the RNA platform, which will impact vaccine research into other diseases.

Parallels are now being drawn between mankind's ability to act quickly to confront the Covid-19 pandemic and our capacity to face down the growing existential crisis of climate heating and biodiversity loss. During my conversation with Bill Gates for this month's cover story, the philanthropist made the point that, while

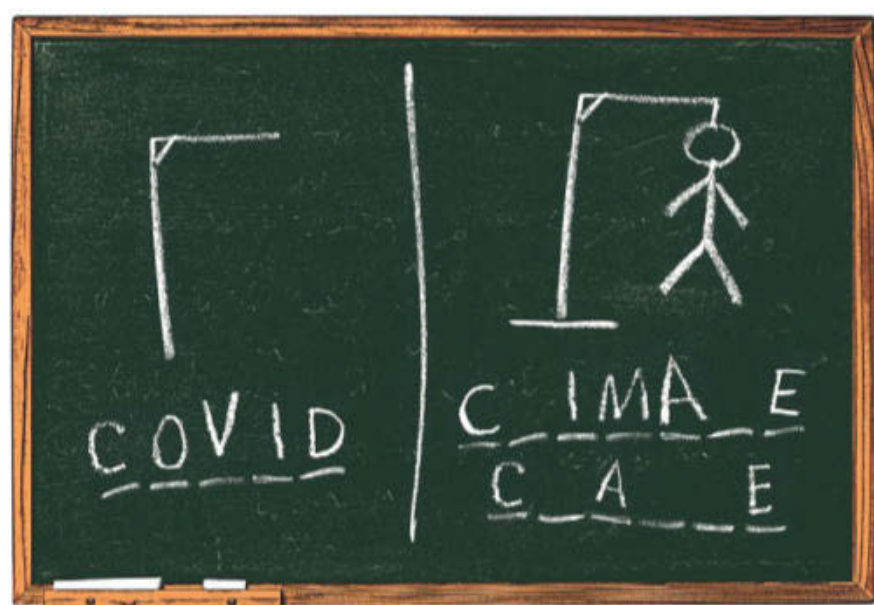
global co-operation on producing a vaccine has been admirable, fixing the climate crisis will be significantly more difficult than tackling the coronavirus pandemic. Disease can be controlled with a silver bullet like a vaccine, but staying below the two degrees Celsius rise in global temperature required to prevent the collapse of Earth's ecosystems will require multiple scientific breakthroughs, the scaling of existing technology, bold financial incentives and dynamic, multilateral governmental partnerships.

China and some western countries have reached a tipping point with electric vehicles, many European countries are producing abundant, clean electricity using solar and wind and there is an appetite from policy-makers to implement the necessary infrastructure, to remove subsidies for

fossil fuels and to price in the cost of carbon to reflect the damage it does. The election of Joe Biden means that there is competence and fact-based decision-making restored to the White House, so once again the US – along with China and the EU – can offer global leadership. COP26 in Glasgow in November will be the most important gathering of global leaders so far this century.

Much has been accomplished, but there is much to do: we will need enormous investment R&D into a number of technologies, including hydrogen, advanced biofuels, geothermal energy, nuclear fusion and fission; there will need to be zero carbon ways of manufacturing fertilizer, steel, plastics and cement and a massive reduction in the cost of carbon capture. This will need multilateral co-operation and co-ordination of capital.

Given the bombshell nature of 2020, I'm loathe to make predictions for 2021, but I'll stick my head above the parapet and say that, while it is the last possible moment to finally address this challenge, 2021 will be the year that humankind – finally – faces up to the reality of the climate crisis.



Greg Williams
Editor

ILLUSTRATION: GREGORI SAAVEDRA



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MISHAEL PHILLIP
PHOTOGRAPHER

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EDITED BY AMIT KATWALA & GIAN VOLPICELLI

START

SIGNS OF

➤ MOVE ON

The “swipe left” draws on the “nope” action in dating apps, and “indicates you have a little sass or attitude. It shows personality when you use it,” says body language expert Patti Wood. “Some think it is rude, while those familiar with it think it’s fun and playful.”

➤ LISTEN TO ME

Many wear AirPods as if they are a piece of jewellery, says Wood, so it can be difficult to tell if someone is listening or not. A “remove” gesture signals the start of a social interaction or conversation, and was adopted in lockdown by teachers using Zoom.

THE TIMES

Humans have always used a constantly evolving visual shorthand that makes communicating in the real world as quick and easy as sending an emoji – and as technology changes, so do our actions. Here's how the latest innovations, from VR gaming to Apple's AirPods, are influencing some of our most common gestures

Language is in a constant state of mutation. As society changes, neologisms sprout, new words become codified – app, selfie, meme, troll – and old ones die out. And the rise of new technologies also impacts our non-verbal communication.

Linguistics professor and digital communications specialist Vyv Evans has suggested that some of our basic hand gestures, or “emblems”, will soon die out due to younger generations not understanding them: like scribbling on your hand in a restaurant to signal for the bill, or making a winding motion to ask someone to lower their car window.

In July 2020, TikTok user Daniel Alvarado documented how his kids put their hands flat against their face

to denote a phone call, instead of the traditional closed fist with outstretched thumb and pinky – this insight earned 2.6m views and an internet meltdown.

The classic “call me” gesture has actually been through several iterations as technology has changed. Body language expert Patti Wood describes how “people over 60 typically do a soft fist gripping gesture, as they first used old dial telephones with the handle-like ear and mouthpiece. And some people do a sort of flip-phone gesture, where the palm is up and the thumb curled.”

Here, Wood explores how the forces of technology and the Covid-19 pandemic are changing our hand gestures, and explains some of the new emblems that have recently emerged. **Harvey James**

This low-contact coronavirus-friendly gesture has crossed from real-world interactions to emails and text messages as a polite emoji sign-off. Wood says that it suggests an awareness and empathy to how the pandemic might have affected everyone differently.



PHOTOGRAPHY: NHUXUAN HUA. MUA: SARAH JAGGER. MODEL: STEPHANIE OMOROJOR. STYLIST: CELINE SHERIDAN



LET’S TAKE A CLOSER LOOK

In virtual reality games, people wearing a VR glove inspect items with a twisting motion, like picking an apple. It’s a niche gesture now, but Wood predicts it will go mainstream, thanks to visual media such as Zoom calls.



IT’S IN THE CLOUD

Referring to information stored in the cloud, it can be used in a meeting, where you can highlight that assets have been shared. Or, it can be a fun reference to something you know, but can’t remember – it’s stuck “in the cloud”.

TEXT ME

“It can indicate an interest in pursuing a romantic or sexual relationship” says Wood, “as well as a way of saying goodbye when a conversation is ending or you are too busy to give someone your full attention at that moment.”

CALL ME

Daniel Alvarado’s viral TikTok video highlights how younger generations put a flat, smartphone-like palm to their ear to indicate phoning someone, rather than the landline-inspired thumb and pinkie between ear and mouth.

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Lindsey Migliore
founded GamerDoc
in response to a
lack of specialised
medical treatment
for esports players



When Lindsey Migliore was six years old, her grandfather bought her a Nintendo 64 and a copy of *Ocarina of Time*. She was captivated. Years later, as a medical school graduate, she still gamed regularly with a group of doctor friends, and they'd end up talking about the pain many of them had begun noticing now and again: a sore pinky, a disgruntled neck or a strained back.

Then, around three years ago, after shoving her ice hockey bag into the boot of a friend's car and feeling a sudden snap at the back of her wrist, Migliore realised years of video games had left her own soft tissues in a troubled state.

"I was working at a hospital, so the next day, I show up and grab an ultrasound, and put it on my muscle," she recalls. "It had signs of chronic injury." The fibres of her muscle, which are supposed to run in neat, parallel lines, were worryingly wavy and irregular – activity including long gaming sessions had caused these micro tears to accumulate, she says. And she's far from alone.

As esports has boomed, professionals and amateurs are committing themselves to long hours of video gaming. But without good nutrition, sleep and care of their physique, many can suffer from numbing or pain in their wrist, hands, back or neck.

Migliore had a form of tendonitis, which can often afflict gamers. Flinging her hockey gear around had just revealed the extent of it. And although

Without good nutrition, sleep and care of their physique, gamers can suffer numbness or pain

her training had predominantly been in traditional sports medicine – she was the physician for her college football and basketball teams – it wasn't long before she decided to turn to esports full-time.

Now she helps esports players take better care of their bodies – publishing tips on YouTube, Twitter and Instagram, pointing gamers toward helpful information and suggesting they speak to their own doctors if they are seeking a diagnosis.

Some pro gamers develop chronic injuries, and experience constant pain that doesn't go away, even when they take a break. Occasionally, some have to retire from esports altogether. Migliore is adamant that, in many cases, this can be avoided. She dismisses the popular idea that gamers simply retire because their hand-eye co-ordination has naturally waned in their mid-twenties and they

HEALTH LEVELS

The Gamer Doctor is in, and she's prescribing better care for esports enthusiasts' bodies

are outpaced by younger contenders.

"We know that's crap," she says, pointing to basketball star LeBron James, who excels at the highest level while well into his thirties. "Did we miss the LeBron James of *Rocket League* because he got a wrist injury when he was 20 and had to retire early?"

One big problem is that doctors aren't familiar enough with the injuries gamers can sustain. In January 2020, Migliore worked with an avid player of *Super Smash Bros* – a high-paced beat 'em up that requires lightning quick reactions and extensive button-mashing. The player's other doctor had told him he had "gamer's thumb" – inflammation of the tendons – but she determined that he actually had intersection syndrome, a similar sort of inflammation caused by overuse, but in a different part of the hand, near the wrist. "We iced the correct area and switched the medication he was on and he was better in two months," she says.

In 2021, Migliore and some of her colleagues are due to publish the first book-length guide to preventing and treating esports injuries, and she's begun working with two medical schools on curricula that covers esports.

It's an attempt to fight scepticism around gaming that Migliore says lingers in the medical field. She recalls being at a conference only a couple of years ago where the topic of video game injuries came up – to the bewilderment of many doctors present. "Half the room started laughing. They thought it comical, people playing video games and getting injured." It's time, she says, for doctors to level-up. **Chris Baraniuk**

Present tense: birthday-gift dramas solved

Kids' birthdays can be a nightmare: parents stress over the right gifts, and if children don't get what they want, abandoned toys can end up in landfill. Melissa Roberts, a 21-year-old entrepreneur from Yorkshire, noticed her older friends' complaints about their offspring's hectic party schedules and started Kidcrowd – a digital platform for family and friends to contribute cash towards something the recipient might actually want. Parents create a profile for their child on the Kidcrowd website, listing the present they are hoping to save for and giving a place to deposit contributions. Brits spend close to a billion pounds on unwanted gifts each year, and that's a huge amount of potential wasted plastic and resources. Roberts' team is working on an app version of Kidcrowd, which should be available by the end of 2021.

Will Bedingfield



START

FLEXIBLE SPACES

Bamboo is reaching new architectural heights in Vietnam – now designers aim to make these sinuous structures suitable for western climates



Around 130km southwest of Hanoi, Vietnam's capital, sits Cuc Phuong National Park, which is Vietnam's oldest – it was consecrated by Ho Chi Minh in 1962 and famously accommodates time-worn limestone ridges and ancient trees. But on its fringes, rising from the shores of a lake, perches a modern structure that both complements and contrasts with the mountains and jungle.

The striking 1,300-square-metre restaurant was completed in October 2020, and is a web of bamboo supporting a domed roof thatched with local ferns, tied in place with ropes. The restaurant is housed in the Vedana Resort, which opens later in 2021, and is part of a boutique hotel collection from central Vietnam.

Using bamboo over conventional building materials is a trademark of Vo Trong Nghia Architects. The firm attracted global attention after constructing the Vietnam Pavilion from bamboo at the Milan Expo 2015, and has used the Asian plant to build resorts, spas, bridges, cafes and conference halls across Vietnam.

The firm's preference for bamboo has to do with more than aesthetics. First, it grows quickly: bamboo is suitable for construction just five years after planting. Second, bamboo branches can be harvested without killing the plant. "This contrasts with wood, which might take decades to grow before it can be felled," says Vo Trong Nghia, the firm's chief architect. "And once we've cut a tree down, it's gone forever."

Besides confronting deforestation in Vietnam, Vo also wants to challenge mining. Rather than extracting marble and granite for interior decor, he prefers to use bamboo, which is both pliable and affordable, and has a unique look.

With a height of almost 16 metres and a diameter of 36 metres, the Vedana Resort restaurant is the firm's biggest bamboo pavilion to date and, in anticipation of orders coming from the west, Vo and his team are now thinking about how to adapt the material to lasting in Europe's colder climates.

"I've already drawn up some ideas to combine bamboo with glass, to seal and insulate spaces while maintaining its structural and visual benefits," says Vo. But warmth isn't the only issue: "The real challenge might be EU construction regulations, which don't yet permit bamboo structures." Joshua Zukas

We've all rolled our eyes at the thought of yet another dreary video call – but what if they were more engaging? Phil Libin's Mmhmm promises to bring TV presenter-style pizzazz to your meetings – plus the debut of AR emojis

When Phil Libin and his team at startup studio All Turtles switched their in-person meetings to remote as the pandemic set in, something felt off. It wasn't an issue of productivity or efficiency; what was missing was fun. "Everything was just kind of boring," Libin says over video chat from his apartment in San Francisco. "Just living on video is hard."

In an attempt to liven things up, he pinned a green camping towel behind him to use as a makeshift green screen, projecting images on to it during virtual meetings – from this, Mmhmm was born.

The app jazzes up video calls via backgrounds, slides and animations, the idea being that in many jobs, success means being able to entertain – tough if you're "a postage-stamp-size head in a box," as Libin puts it.

When you use Mmhmm, you can select a virtual "room" as your background (Libin opts for a tasteful bookcase) and show slides featuring text, images and video, which appear either full-screen or in a box behind or beside you, like you're a weather presenter. Additional functions include a pointer tool, filters and emoji reactions; Libin demonstrates "Big Hand" mode, which uses gesture recognition to display a cartoon giant foam hand when he does a thumbs-up (he admits that the etiquette for this new visual vocabulary may need some thought).

As well as zhuzhing up a live meeting, you can record yourself giving a presentation with Mmhmm and then send a link for others to watch at their leisure, either like a video, or to flick through like a slide deck.

Mmhmm is not intended as a direct competitor to existing video conferencing tech. You still need to run the call through a compatible platform such as Zoom; Mmhmm acts as the camera input. This means



Phil Libin, CEO of Mmhmm, and the virtual foam hand that appears when he gives a thumbs-up during Zoom calls to colleagues

that you can use Mmhmm, but others on the call won't need to download it too. Platforms such as Zoom encourage third-party apps, although Libin admits firms may build similar functionality themselves. "Every time there's such a big technological change, this happens – you don't know who's going to be a great partner and who's going to be a competitor," he says. "Often, it's both."

Libin previously co-founded four companies including note-taking app Evernote, which he left in 2016, and All Turtles, which Mmhmm was spun out of (he is CEO of both). Mmhmm raised \$21 million (£16m) in series A funding in October and acquired Memix, which makes digital filters and visual effects. He says that the company philosophy is to make money through direct revenue rather than advertising or selling data: there's a premium option with more features for \$9.99 a month, and planned enterprise versions will offer businesses a custom "professional video presence".

Post-Covid, Libin says the demand for video will remain, with most jobs (and other activities) becoming hybrid. "Almost every experience is going to be a combination of video and in-person, live and pre-recorded," he says. But just as mobile apps aren't simply shrunk-down versions of PC software, video meetings will find their own format. For Libin, the point is not to play catch-up, but to jump ahead, and make full use of the extras video allows for. Maybe one day it'll seem strange not to have a giant smiley emoji appear when you make a heart gesture with your hands. "The way that we're going to be doing video meetings a year from now is not going to be like trying to recreate the old reality, which no one really liked very much to begin with."

Victoria Turk *mmhmm.app*

SHOW AND TELL: ZOOM CALLS CAN BRING THE FUN



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FOOD FOR EVERY TABLE

Israel has become an unlikely hotbed of alt-meat innovation, but rabbis are asking the question: can fake steak be kosher?



For a small country, Israel has a disproportionately high number of alt-meat startups – more than 50, according to Nir Goldstein, managing director of the Good Food Institute Israel. “It’s a hot market. We don’t know of any alt-protein startup that hasn’t been able to raise seed funding,” says Goldstein. The Israeli government also funds two food-tech incubators, The Kitchen and Fresh Start.

Plant-based analogues dominate the scene: Rilbite’s minced-meat alternative is made from eight grains and vegetables, while More Foods’ faux beef strips use a high-protein yeast blend “to create a novel taste and texture [that] resembles whole-muscle cuts,” says founder Leonardo Marcovitz.

Some companies are also turning to 3D printing. Redefine Meat’s Alt-Steak emulates the texture and structure of the real McCoy by digitally mapping over 70 parameters of beef, such as fat patterns; SavorEat’s robot chef 3D-prints and cooks “burger” patties.

But on the other side of the kitchen is cell-based or cultured meat. It involves

growing cell cultures taken from a live animal, so it’s not vegan, but it is cruelty-free and vastly reduces the resources used to produce meat. “Once the cells are obtained, they are fed with nutrients that enable them to multiply within a fraction of the time required to grow conventional meat, and without antibiotics,” says Didier Toubia, whose company Aleph Farms has developed a thin-cut beef steak (*shown left*) this way.

While innovation in this field is flourishing, many Jews in Israel and elsewhere might be wondering whether cell-based meats would be considered kosher. “At the moment, it’s impossible [for the Jewish community] to reach a decision, as production methods have not been fully formulated or disclosed,” says rabbi Joel Kenigsberg. “The critical question is the source of the cells: were they derived from a kosher species? And was the animal alive when the cells were taken, or had it undergone ritual slaughter? Now is the time to find production methods that meet kosher requirements.”

But the rabbi recognises the benefits that cell-based meat can bring. “The broader question we always face is: should we embrace this new technology?” he asks. “If cell-based meat can live up to its promise of sustainably feeding the global population – of being good for both humanity and planet – then I think the answer will be a resounding yes.” **Delle Chan**

ALEPH FARMS’
THIN-CUT
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COW CELLS

THE CELLS ARE
FED NUTRIENTS
AND MULTIPLY
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AS THEY WOULD
NATURALLY

IT TAKES JUST
3-4 WEEKS
TO “GROW” A
STEAK, VERSUS
2-3 YEARS
RAISING A COW

WIRED insider

Events, new products and promotions
Compiled by Jake Pummintr



Patek Philippe Ref. 6301P-001 Grande Sonnerie Price on request patek.com

Powered by the 703-part GS 36-750 PS IRM movement, Patek's intricate timepiece wraps the Grande and Petite Sonnerie chiming mechanisms in a platinum case with a black enamel dial.

Moodo AIR 2-in-1 Air Purifier and Aroma Diffuser £196.90 moodo.co

Optimise your WFH setup with the app-controlled Moodo Air. It can scent your space using one of 32 recyclable fragrance capsules, while also purifying the air you breathe – its HEPA filters remove pesky particulate matter such as pollen, dust and mould.



Allbirds Wool Dasher Mizzle shoe £130 allbirds.co.uk

Engineered for running in the rain, the Wool Dasher blends ZQ-certified Merino wool, SweetFoam (a sugarcane-derived carbon-negative green EVA material) and FSC-certified rubber. It also features Allbirds' PuddleGuard fluorine-free water repellent.

Tom Ford Costa Azzurra Eau de Parfum £85 for 50ml tomford.co.uk

Banish your winter blues with a spritz of summer from Tom Ford's Costa Azzurra. This EDP's top notes include driftwood, oud and seaweed; middle notes cypress and citrus; and the base vetiver and oak.

THE INSIDER EVENT EDIT

WIRED HEALTH

wired.uk/health-event

March 31, 2021

Join our thought-provoking healthcare disruptors, scientists and practitioners. This year's Startup Showcase, in partnership with EY, will run as a separate hour-long session on March 24.

-

WIRED HEALTH:TECH 2021

wired.uk/health-tech

September 22, 2021

Revealing the most compelling advances in the future of patient care – speakers at the 2020 event included mRNA Covid-19 vaccine creators Tal Zaks, chief medical officer, Moderna, and Ugur Sahin, co-founder and CEO, BioNTech.

-

WIRED SMARTER

wired.uk/smarter

October 12-13, 2021

Explore trends in business, retail, money, the future of work and sustainability. Past speakers include Black Girl Ventures founder Shelly Bell.

-

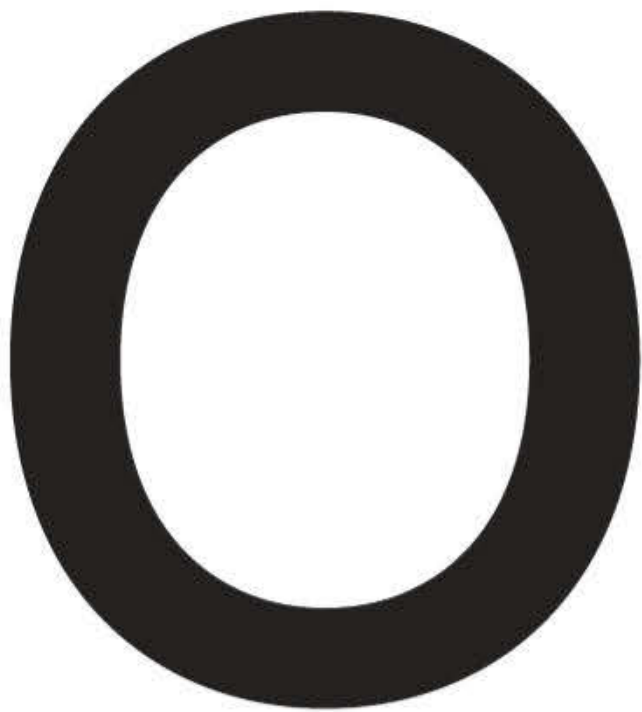
WIRED LIVE

wired.uk/wired-live

November 23, 2021

The inspirational festival for innovators, entrepreneurs, strategists and designers, it brings the WIRED brand to life with a host of speakers, from politicians to pop stars.

In response to Covid-19, WIRED has a virtual-only option for its conferences running until at least April 2021. Details of any in-person experiences will be shared closer to the event.



ver the last five years, AI has seen rapid improvements in its ability to generate synthetic versions of people's faces and voices – commonly known as deepfakes. Generating the earliest deepfakes required powerful computers and technical expertise, but deepfake creation is being increasingly democratised.

Deepfake smartphone apps let anyone create deepfake likenesses and, while these aren't especially lifelike, more sophisticated technology has created photorealistic images of non-existent people.

Creating these realistic deepfakes still requires expertise and high-end hardware. *South Park* creators Matt Stone and Trey Parker spent millions and employed 20 professional "deepfakers" and VFX specialists to create a satirical show, *Sassy Justice*, which follows a small-town TV reporter with Donald Trump's face as he encounters deepfaked celebrities.

But technical expertise and financial resources may not be barriers for much longer, as developers race to harness deepfakes' potential to define a new generation of social content. One company leading the way is Ukraine-based Reface, whose face-swapping app had been downloaded over 20 million times by mid-August 2020. Reface's CEO, Roman Mogylnyi, told TechCrunch that planned upgrades to enhance the app's deepfake quality include full-body swaps. To Mogylnyi, the future of deepfake apps represents "a personalisation platform where people will be able to live different

lives during their one lifetime." But the commodification of advanced deepfake apps raises questions about how they could potentially be misused.

Glimpses of this are already visible. One of this article's co-authors discovered a "deepfake pornography bot" on the Telegram app, which allowed users to upload pictures of clothed women and "strip" them by generating a deepfake nude. Over 100,000 deepfake images of women and minors were shared on Telegram channels counting over 100,000 members.

Fears that deepfake apps could fuel political disinformation and deceptive content were sparked in April 2020, when Donald Trump retweeted a crudely manipulated video of Joe Biden lolling his tongue and twitching his eyebrows. That video wasn't realistic, but similar future scenarios may be more convincing. Both examples point to a future where deepfake apps could create harmful fakes on a massive scale, threatening anyone whose images are online.

Many deepfake apps address these concerns by being "on rails": users can only swap faces into a selection of pre-approved scenes. But these restrictions are often the outcome of technological limitations rather than a deliberate security choice – in order to quickly generate high-quality face-swaps with one or a few user images, apps have to "pre-train" their generative models using only the approved footage. As the technology becomes more powerful and pre-training less restrictive, developers might see a competitive advantage in opening up their apps to user-uploaded content in an "off-rails" approach.

Other technology companies offering potentially hazardous services such as lip synchronisation and voice synthesis have adopted policies to prevent their products being misused – such as individually vetting clients and gaining permission from all parties whose likeness is being altered. Yet it's difficult to imagine deepfake apps enforcing similar protocols, given their reliance on uptake by a large number of users eager for novelty. As apps vie for users' attention, it seems almost inevitable that they'll "go off the rails".

LET'S GET REAL ABOUT DEEPFAKES

The popular face-swapping tech has developed a dark side that's going to need vigilance and tough legislation

Henry Ajder is a leading adviser on deepfakes, disinformation and media manipulation, and an expert on the relationship between tech and society



Nina Schick is a broadcaster, author of *Deepfakes: The Coming Infocalypse*, and a specialist on the impact of technology on society



Both Apple and Google have implemented bans on apps that create deceptive or malicious deepfakes from their app stores, and developers are working on security features to avoid falling foul of these policies, such as app-specific deepfake detection tools, automatically blocking pornographic or malicious content, and the watermarking of deepfakes.

While developers’ readiness to address misuse of their apps is promising, deploying these security features poses several challenges, including how to roll them out. For detection tools to be effective, they

would not be feasible given the volume of content.

Given all this, what could be plausibly done to minimise deepfake apps’ misuse? One approach could involve the creation of an app safety framework for developers, including measures such as threat assessments, limited access without user authentication, or even moratoria on releasing new capabilities that lack harm-mitigation strategies. If such a framework were enforced by app stores and other stakeholders, it could help create a safety standard for deepfake apps that all developers would have to follow.

A stronger reaction may involve new legislation that allows victims or authorities to hold developers to account if their deepfake apps are deemed open to, or intentionally designed for, misuse. This could entail fines, payment of damages to victims, the removal of apps from app stores, or criminal charges against the developers. These approaches

The more powerful deepfake apps become, the harder it will be to prevent their harms

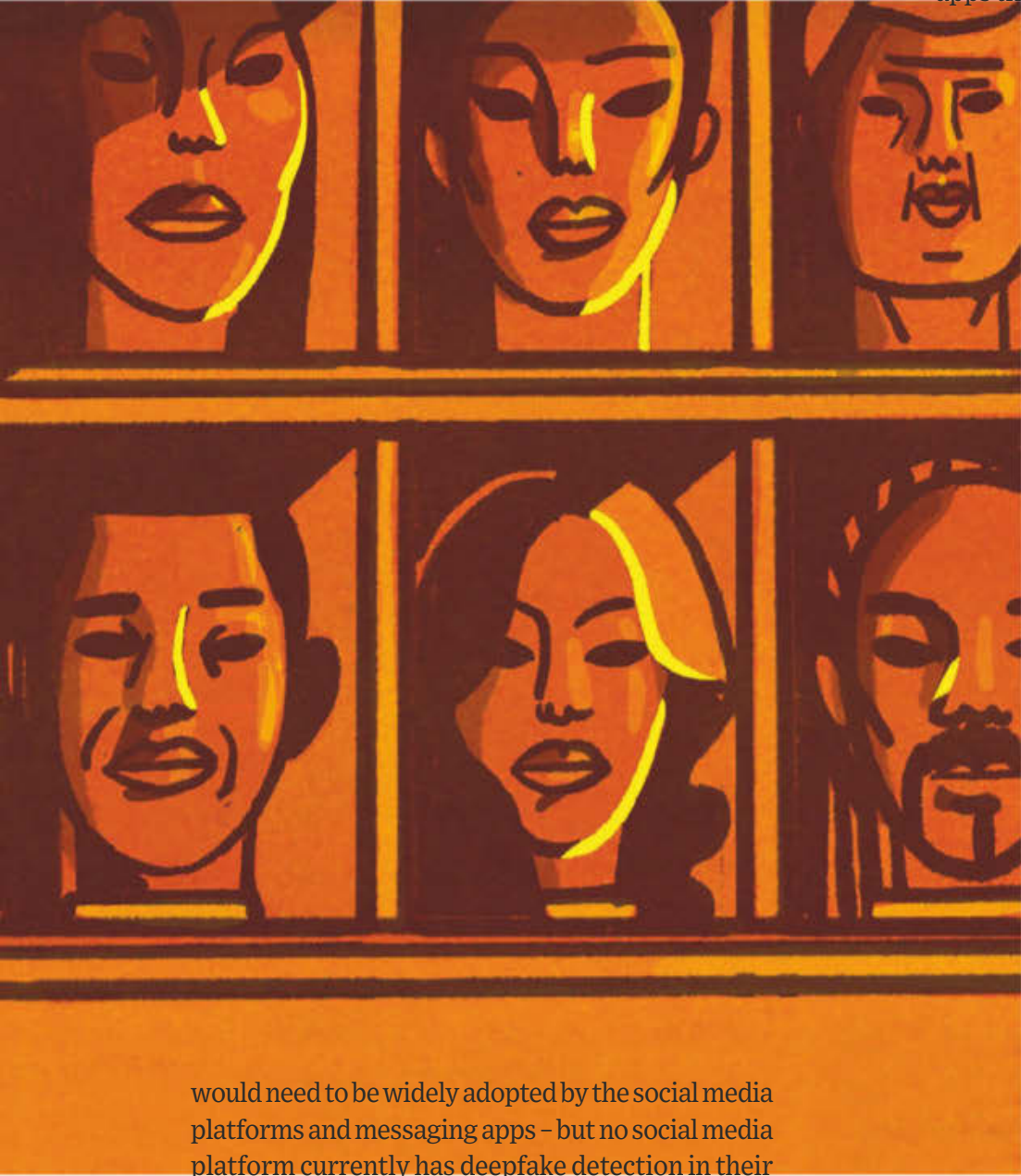
target deepfake apps’ shift to “off the rails” by either restricting who can access them and what capabilities are released, or punishing developers if this shift causes harm.

There is clearly an inherent friction with the model deepfake apps are moving towards: the more open and powerful they become, the harder it will be to prevent the harms they can cause. Striking the right balance of openness and safety will be essential to deepfake apps’ future success. If they continue to move toward “off the rails”, this balance will be very difficult to achieve.

would need to be widely adopted by the social media platforms and messaging apps – but no social media platform currently has deepfake detection in their media upload pipelines, and implementing detection on messaging apps like WhatsApp or Telegram would require monitoring users’ conversations.

Another is how reliable these security measures would be. A watermark would notify viewers that a video is fake, but developers might be reluctant to place one where it would obstruct the image entirely, meaning it could simply be cropped out of frame. Pre-emptively detecting and blocking malicious content would also prove difficult given the wide range of possible harms that could be wrought through this budding technology. Capturing the near-limitless variety of malicious uses is currently impossible to automate, while manual moderation

ILLUSTRATION: ELODIE LASCAR; MATTHEW GREEN



WIRED	TIRED	EXPIRED
Gatwick drone	Croydon cat killer	Loch Ness monster
Civic hackers	GDS	Olgino trolls
Beth Harmon	DeepBlue	Bobby Fischer
Protein-folding	Carb-cutting	Fat-burning
mRNA	M&A	MBA

STAYING IN HAS NEVER BEEN SO TERRIFYING

When you're not allowed to leave the house, Swamp Motel brings its immersive escape room to you

S



Swamp Motel knows how to put on a show, even when the audience can't come. Founded by Ollie Jones and Clem Garritty, alumni of experimental theatre troupe Punchdrunk and members of comedy group Kill The Beast, it blends immersive storytelling and brand tie-ins with West End production values.

Since its launch in 2017, London-based Swamp Motel has built a zombie-filled police station for Capcom's *Resident Evil 2*; brought a sinister circus to Shoreditch for Verizon; and transformed Dishoom's Kensington restaurant into an Art Deco jazz den. Guests both spectate and perform, solving mysteries, plotting escapes and adding to the atmosphere. "I think that's really key to feeling immersed," says Jones. "You're not inhabiting a character, you're not stepping through a door and becoming someone else. It feels like it's happening

in your life as you live it. You just enter into a world."

2020 should have seen Swamp Motel launch its first independent productions. But when March's lockdown made public events untenable and 95 per cent of their commissions were cancelled, they knew they'd have to either pack it in – or pivot.

"We thought, 'Why let [the pandemic] stop us?'" says Garritty. "Usually, there's an auditorium where audiences are sat, and we want to drag them out of their seats and give them something more thrilling. So we started looking at Zoom as that auditorium."

In May, Jones and Garrity launched *Plymouth Point*, an immersive theatre experience designed for the Covid era. Inspired by *Rear Window*, Alfred



The Swamp Motel squad (l-r): Daniel Hemsley, managing director; Clem Garritty, co-founder and creative director; and Ollie Jones, co-founder



Hitchcock’s classic tale of voyeurism, and Netflix’s crime-doc *Don’t F*** With Cats*, the 90-minute play invites groups to be detectives on Zoom, watching pre-recorded videos, hacking social media accounts and trawling the internet to solve a creepy missing person case.

“We tried to make it intuitive. You don’t need to be good at anything, you just need to know how to follow the link to the chat,” Jones explains. “It’s another way of socialising and playing a game without having to leave your house, which we did like to do, even before lockdown.”

Crafting the narrative was fun and familiar, but the tech brought headaches. Their initial reliance on live moderators to guide each group’s experience, for example, limited ticket sales; and hundreds of failed password guesses from around the world eventually raised red flags with the provider they’d used to create a fake email inbox.

There also seemed to be no way around the inevitable frozen screens and dropped connections, so Swamp Motel added pre-planned glitches into the story. “It doesn’t remove you from the world at all, but it does get us out of a lot of difficult questions as to why [a certain character] isn’t listening, or why she’s suddenly gone off screen. It’s like... that’s tech,” Garritty explains.

In October, they launched the second chapter of the story, *The Mermaid’s Tongue*, revolving around a missing archivist guarding a shocking secret. Zoom has been replaced with a bespoke video platform where an AI classmate provides automated clues to help players along. (A live person still monitors each game and will jump in to help the truly

desperate.) Swamp Motel has also expanded the playing field, creating their own web pages and hiding clues in obscure corners of the internet.

So far, Swamp Motel’s pivot to digital seems to have been a success, with more than 15,000 players from around the world having joined in. The final chapter of the trilogy is set to launch in February 2021 and, due to the series’ popularity, all three will be available to play until April – much longer than the modest three-week run the team envisaged.

While they’re looking forward to making real-world productions again, the duo insists the end of social distancing won’t mean the end of their digital offering. “This has opened our eyes so much to just how we can engage with people, how we can partner with new people, how we can reach new audiences,” Garritty says. “Going forward, we’d obviously love to get back to building live events again, but I don’t think it will be instead of [the digital shows]. I think this will now become an extension of everything we build.” **Allyssia Alleyne**

Early adopters
Three entrepreneurs
reveal what’s caught
their attention in
lockdown self-care



Sharmadean Reid
Founder of
Beautystack

“L’Oréal Paris has launched the first ever digital make-up line for live video. During the pandemic, beauty brands have been rethinking product testing (no makeup samples anymore) and e-commerce: the crisis has become a driving force of innovation, which is brilliant.”



Chika Russell
Founder of
Chika’s Foods

“Kegel balls, also known as vaginal exercise balls, are awesome for pelvic floor exercises. Three kids later and I am in pretty good shape. It helps with confidence and ultimate happiness – which makes me a better mum, partner and business leader.”



Nessa Keddo
Founder of
Munch Free

“I’ve been loving Steven Bartlett’s ‘Diary of a CEO’ podcast. It’s really useful relating to a business owner who’s trying to connect with some of the difficult issues in the world. I haven’t got much time to read at the moment, so it’s a good ‘on-the-go’ listen.” **AL**



**Knowledge is power:
DIY editing on Wikipedia**

Accessed over 15 billion times a month, Wikipedia is hugely influential, but 20 years after launch, it still has a ways to go: articles on white men dominate, for example – but it’s an easy fix. Jess Wade, a physicist at Imperial College London, shares her five tips for impactful editing.

1. Play by the rules

Remember that Wikipedia is non-partisan, impartial and aggregates reliable sources to summarise knowledge. There are rules on what and who counts as “notable” and worthy of an entry – and writing about yourself, your family or your boss is a clear conflict of interest.

2. Citations and saves

A Wikipedia page is only as good as its reference list. For every sentence you type, try and add an appropriate citation. Wikipedia’s visual editing interface looks like a Word document, but there’s no autosave – click “publish” often, so you don’t lose your work.

3. Don’t plagiarise

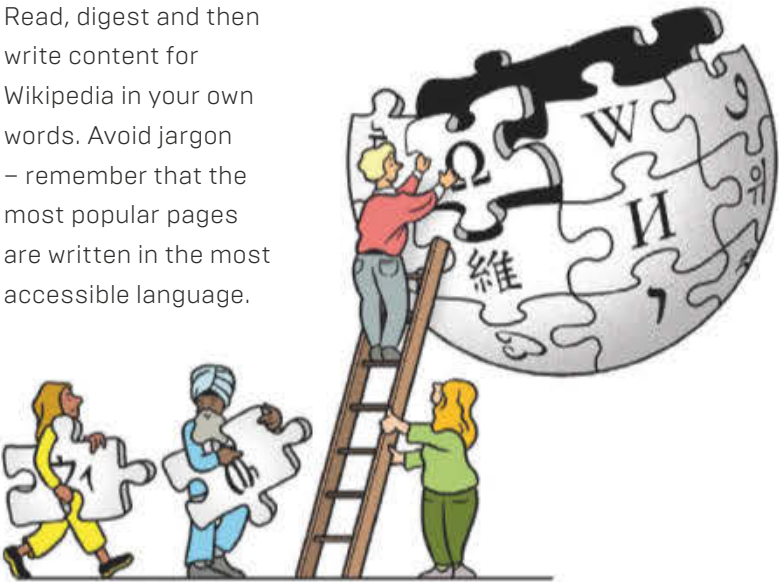
Read, digest and then write content for Wikipedia in your own words. Avoid jargon – remember that the most popular pages are written in the most accessible language.

4. Assume good faith

The Wikipedia editing community is by no means reflective of the population it serves, but they’re not all sitting behind their laptops waiting to delete your work. Join edit-a-thons, listen to experienced editors’ suggestions and use the talk pages to discuss any issues.

5. Be bold

Wikipedia is an open-source, collaborative project whose guidelines and policies evolve every day. Don’t worry about making mistakes – changes can be reverted – and remember that with every biography you update and typo you catch, you make the internet a better place.

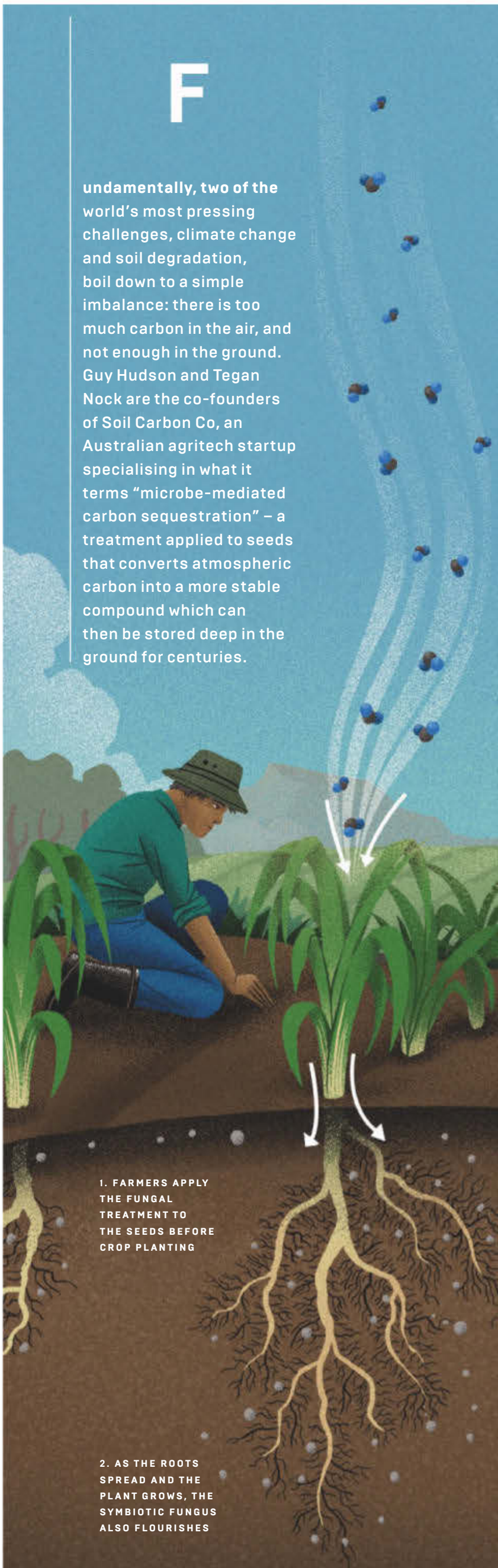


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undamentally, two of the world’s most pressing challenges, climate change and soil degradation, boil down to a simple imbalance: there is too much carbon in the air, and not enough in the ground. Guy Hudson and Tegan Nock are the co-founders of Soil Carbon Co, an Australian agritech startup specialising in what it terms “microbe-mediated carbon sequestration” – a treatment applied to seeds that converts atmospheric carbon into a more stable compound which can then be stored deep in the ground for centuries.

1. FARMERS APPLY THE FUNGAL TREATMENT TO THE SEEDS BEFORE CROP PLANTING

2. AS THE ROOTS SPREAD AND THE PLANT GROWS, THE SYMBIOTIC FUNGUS ALSO FLOURISHES



The star ingredient in the seed treatment is a blend of microbial fungi called “dark septate endophytes”, which live symbiotically in the roots of the host crop. They convert CO₂ absorbed through photosynthesis into fungal melanin compounds, which are less susceptible to breaking down upon contact with water. These compounds are then deposited in soil microaggregate – tiny clumps of soil that provide an oxygen-free environment conducive to long-term carbon storage. “Carbon increases the water-holding capacity of the soil, and also helps capture and retain nutrients, translating into higher yields and better productivity,” says Nock.

Investors are sold: in June 2020, Soil Carbon Co

raised AUD\$10 million (£5.5m) in seed funding in a round led by Horizons Ventures, the private investment arm of Hong Kong tycoon Li Ka-shing.

This capital injection is enabling Soil Carbon Co to go mainstream. Nock and Hudson are currently trialling their seed treatment on crops such as canola, soybean and wheat in Australia and the US, and hope to bring it to market later in 2021. Fortunately, a major selling point of Soil Carbon Co’s technology is that it is low-cost and easy to adopt, unlike many of the regenerative agriculture

methods being practised today, such as no-till farming. Essentially, all farmers have to do is inoculate their crops with the microbes – which will be sold in freeze-dried form – and let nature take its course. What’s more, it is highly scalable. “You already have a workforce of about a billion farmers globally, who spend every day working at the intersection of atmosphere and soil, and who deeply understand that interface,” says Hudson. “You also have ready infrastructure in the form of crops, which are effectively like miniature

fans, constantly sucking atmospheric carbon down into the soil. This all means that we have the capacity to draw down enormous amounts of carbon within a short time-frame.”

It’s certainly an elegant solution – one that could help avert climate catastrophe and sow the seeds for a greener future. “Hopefully, our technology will buy the rest of the world some time to transition away from fossil fuels and to a cleaner economy,” says Hudson. “While it is not going to solve climate change, we want to give humankind a fighting chance.” **Delle Chan**

25%
Percentage of atmospheric carbon Soil Carbon Co’s technology can potentially capture if it is applied to crops globally

3. THE PLANT
ABSORBS
ATMOSPHERIC
CARBON VIA
PHOTOSYNTHESIS

4. DARK SEPTATE
ENDOPHYTES
CONVERT THE
CO₂ INTO FUNGAL
MELANIN COMPOUNDS

5. THE FUNGAL
COMPOUNDS ARE
STORED IN THE
OXYGEN-FREE SOIL
ENVIRONMENT

THE FUNGAL FARM

Growing crops can also help capture and sequester atmospheric carbon – and all it takes is a few added microbes...

Downloadable dystopia

General misery? There's an app for that...

Over the years, smartphone apps have ranged from gimmicky to game-changing, but more recently, they've begun to reflect our confusing, dystopian times. Hopefully, in 2021, we can all get back to Candy Crush, but here's our pick of the current downloads that are a total downer. **AK**



CIVVL

Described by Vice as "Uber, but for evicting people", gig economy app Civvl boasts that it is perfect for landlords. It allows property owners to summon freelance goons and process servers to boot renters out of their homes at the touch of a button – evictions being one of the few growth industries during the pandemic.



STAFFCOP

As we settled in to working from home, bosses had to trust their employees would do their jobs unobserved. For those who couldn't, creepy stalkerware like StaffCop, which lets firms keep tabs on workers' activity, flourished. There are also fears that wearables aimed at measuring social distancing could be repurposed to track productivity.



PURPLEAIR

During the now-annual wildfires in California, weather apps were demoted from their morning check-ins in favour of Purple Sky, which tracks air quality in real time with data feeds from thousands of sensors. On one day in September, the app was visited more than half a million times, as acrid smoke blotted out the Sun.



FACEBOOK CAMPUS

The social media network's latest innovation is a new version of the platform that's accessible only to students – which, if you recall, is exactly how Facebook started life before it morphed into a world-destroying behemoth. Having devoured the public discourse, Facebook is now eating itself.



Cecilia Harvey spent nearly 20 years on Wall Street, working capital markets for the likes of Accenture, Citi and HSBC. And yet it feels almost natural that her road has now led her to healthcare. Growing up, she was surrounded by generations of nurses and support workers, who streamed in and out of her childhood home in New York.

"Everybody in my family worked in a hospital – my mother, my grandmother, my grandmother's older sister, and my two aunts," she explains. "I remember sitting at that kitchen table and watching each of them come home exhausted, and hearing the stories that they told me about the patients that they cared for, many of whom came from communities that I grew up in, where [they didn't have] access to certain higher quality healthcare services."

Now, Harvey is primed to make her own mark in the medical field – not as a front-line carer, but as CEO of Hyve Dynamics, the sensory technology company she co-founded in 2019. Its health-monitoring armband, unveiled in September, offers a new way to detect symptoms of illness – an innovation with urgent implications as the world faces down the threat of coronavirus.

Constructed from plastic and thin, bamboo-derived fabric, the armband is embedded with lightweight sensors that track multiple points of wearer data in real time, including heart rate, respiration, temperature and blood oxygen levels. Worn throughout the day, it can collect comprehensive data about how a person's vitals change over time, and wirelessly transmit this information for remote monitoring by a practitioner.

But what makes this device more than a glorified Fitbit is that the technology can register patterns in physiological changes (an intermittent fever, for

example, would register differently than a continuous one) and show how the timings of certain changes coincide. If multiple symptoms of coronavirus are detected in the early stages of infection, the individual can then be flagged for testing and isolation early, reducing their chance of spreading the illness to others and ensuring they receive the right treatment in a timely manner.

This venture into healthcare is a drastic change in direction for Hyve. Until recently, the company had prior-

itised developing sensory technology solutions for the aviation, automotive and gaming industries, building on co-founder and head of research Juan Sebastian Conde's developments in the world of aerospace engineering.

The increasingly worrying spread of Covid-19 around the globe changed things overnight. In March 2020, after a phone call with her mother and aunt, who are still hospital workers, Harvey began looking into the symptoms of the virus. When she noticed that the virus's key

symptoms could be detected by Hyve's technology, a pivot seemed necessary.

"The next day, we released a press release not only [highlighting] what our sensor tech can do within this space, but also a call to other companies and people within government to work together on trying to tackle this," she says.

The message seems to have been received: in September 2020, software platform Vantiq announced it would be partnering with Hyve to further develop their remote healthcare monitor.

Harvey, who has lived in the UK for the last 13 years, hopes that by equipping businesses, schools and hospitals with the armband, Hyve can aid not only in the containment of Covid-19, but also help to lessen the widespread fear around infection. And even after the pandemic has subsided, she believes they could provide a lifeline for remote, elderly and low-income communities that struggle

← Hyve Dynamics CEO Cecilia Harvey wearing the health-monitoring armband that can detect Covid symptoms

with access to healthcare by allowing medical professionals to accurately track their condition from afar, while alleviating the pressure on providers contending with capacity constraints.

"This pandemic has exposed some serious gaps within our healthcare services and severe inequalities in both the treatment and the wellbeing of people from different demographics," Harvey says. "Sensor technology can really help to bridge those gaps by providing much more equal access to basic healthcare services, and also by protecting the public as a whole."

Allyssia Alleyne hyvedynamics.com



A WEARABLE EARLY WARNING SYSTEM

How the health crisis spurred a change in direction from avionics and gaming to healthcare

A

s businesses prepare for the new normal, now is the time to make smart decisions about the future. By 2023 it's estimated that companies worldwide will invest \$1.1tr in Internet of Things (IoT) technologies, while the number of connections will top 3.5bn devices and sensors according to market intelligence company IDC. It's a step towards creating the digital-defined business, where data drives decision making.

"The 'haves' and 'have nots' of the business world are becoming obvious," says Anne Sheehan, director of Vodafone Business UK. "And it is technologies such as IoT that are proving to be the differentiator to introduce more efficient processes or generate new revenues." Sheehan points to the company's recent report which found that 87 per cent of UK businesses that implemented IoT technologies have already seen tangible returns. "This is a competitive edge today that will

The Internet of Things is helping to create a more sustainable future

From construction to manufacturing, utilities to public transport, Covid-19 exposed many shortcomings of the pre-pandemic world. But investing in the right technologies can get it back on track

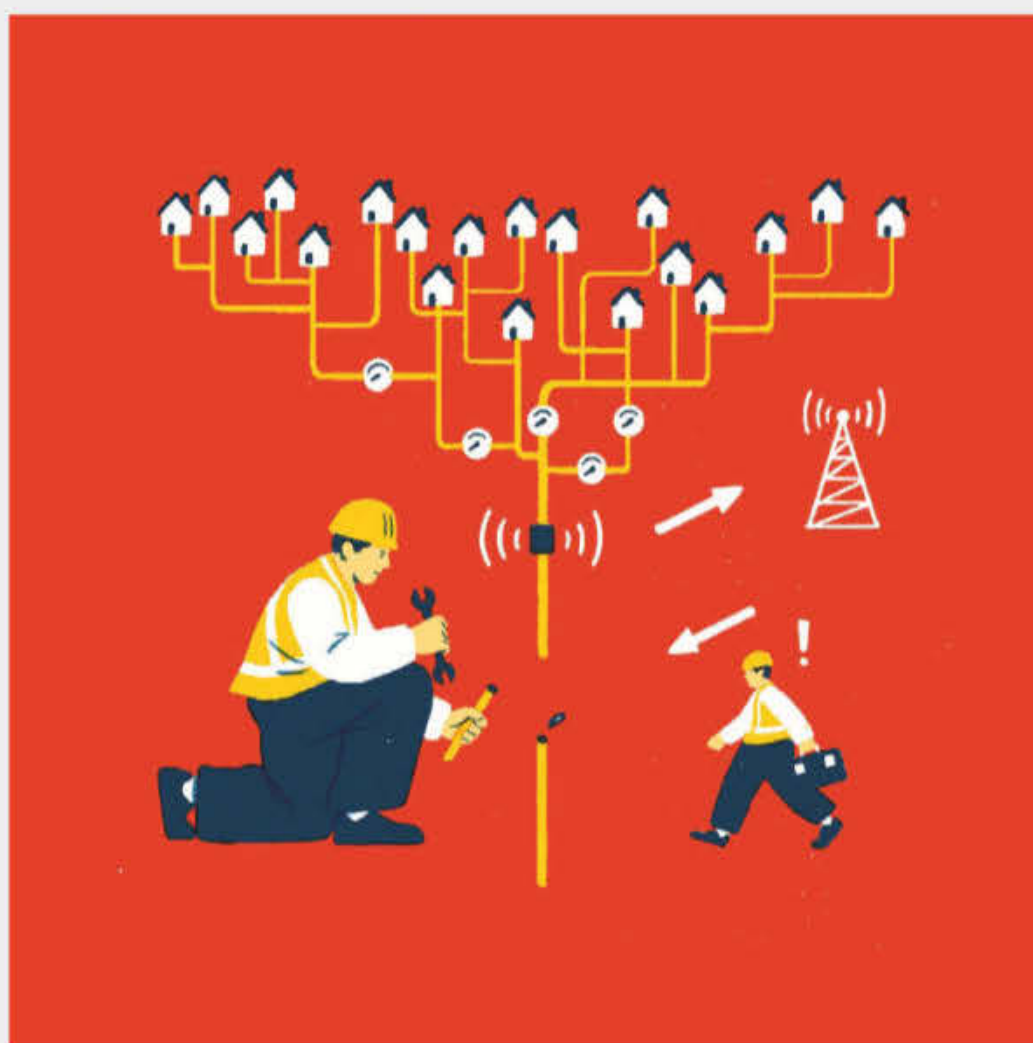
only become more apparent," she says.

But what do those numbers actually mean? Take water as an example: across the UK, about 23 per cent of the water that runs through underground pipes is lost to leakage, more than three billion litres a day – or 1,200 Olympic-sized swimming pools. The industry has set itself the target of reducing water leakage levels by 15 per cent in the next five years – but some are going further still. SES Water, a utilities firm that provides water to approximately 730,000 people in East Surrey,

parts of West Sussex, West Kent and South London, is using IoT-enabled underground sensors to monitor pressure, flow, temperature and acoustic signals to pinpoint the exact location of leaks in its network.

The collected data is then transmitted using IoT technology and relayed back to its headquarters in Redhill, Surrey. The use of the narrowband network is crucial as it allows data to be transferred up through the ground quickly and reliably. When a pipe develops a leak, the sensors allow SES engineers to locate its exact co-ordinates and fix the issue before it has an impact on customers. The network of sensors was recently updated to use narrowband IoT technology, allowing data from the water supply network to be sent every 15 minutes rather than every hour. The project is part of a ten-year partnership between SES and Vodafone. By 2045, SES plans to reduce leakage by 50 per cent. "Vodafone is focused on using innovation to give businesses new ways to help them adapt and thrive," says Sheehan. "These technologies are about delivering better business outcomes today, and a roadmap for transformation in the future."

SES isn't the only company investing in this area. ABI Research, a market advisory firm, estimates the utility industry will spend \$14bn a year by 2023 to modernise and build smarter infrastructure. Across all utilities, from water to gas and electric, greater access to data and intelligence can



Fixing water leaks is easier with IoT-connected pipes and infrastructure

ILLUSTRATION: HARRY TENNANT



help businesses improve efficiency and reduce costs, and have greater visibility over their networks to enable proactive rather than reactive maintenance.

Research by IT services company ATOS suggests half of energy providers are now trying to reposition themselves as lifestyle-focused companies. Giving customers smarter tools to monitor and manage their energy use, or just manage their account, all relies on a deep understanding of what's happening across the energy network. Vodafone's Smart Utilities service wraps this all into an end-to-end package that gives companies bespoke, highly-secure solutions and complete visibility of their network.

Challenges faced by public transport companies remain unchanged – even as Covid-19 sent demand tumbling – operating using increasingly finite resources while meeting climate crisis targets and striving to realise customer expectations of a modern, reliable service.

To deliver on all of these challenges – and prepare for a world of flexible working

'These technologies are about delivering better business outcomes today, and a roadmap for transformation in the future'

and long-term social distancing – public transportation companies will rely on one thing above all others: data.

By using IoT to monitor and maintain their networks, the companies who keep us all moving will be able to improve efficiency, minimise disruption and improve the customer experience by providing reliable and relevant information – crucial for building trust. Similar pressures are being felt by companies in the business of moving goods. According to PwC, 90 per cent of transport and logistics companies place a high importance on data and analytics for decision-

**IoT tech can enable
public transport
real-time data and
smart logistics**

making, more than in any other industry.

That data-led future is already being realised. In South Africa, IoT.nxt®, a part of the Vodafone Group, has worked on a trials with a major port to integrate IoT technologies into one of the world's busiest shipping hubs. The work is designed to improve the visibility of assets while providing telemetry and enabling predictive maintenance by tracking and monitoring everything from vehicles and container trains. The trials have been successful – a full production deployment will have a major impact. Sensors fitted to cranes also help engineers plan maintenance. An IoT platform will allow ports like this to hyper-connect all their 'things', collect relevant data and build insight-driven results that will help manage scheduling and track capacity issues.

While much of the world was on lockdown, construction barely paused. In the UK, companies in this sector are working to meet a government target of building 250,000 new homes every year while also substantially reducing emissions, costs and speeding up delivery. Many construction firms are reassessing and redefining how they work – and IoT technologies are coming to the fore. Vodafone's end-to-end IoT solutions allow construction companies to connect and activate services of new sites within 48 hours, helping to get the right assets and people on site straight away.

Greater access to data about what's happening on-site can help construction companies monitor vehicles and machinery in real time, helping to analyse and manage equipment costs and create a smart, responsive infrastructure to support workers in their day-to-day tasks.

Across all industries, investment in the IoT is delivering tangible benefits – from increased efficiency and agility to smarter insights and new possibilities, bespoke, end-to-end Internet of Things solutions are helping companies build for the future, whatever the new normal might be.

Discover how Vodafone Business can help you make the most of the Internet of Things at vodafone.co.uk/business/iot

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HOW AND WHEN TO SHIFT CAREER GEARS AND RUN
A BUSINESS THAT TRULY INSPIRES YOU

PHOTOGRAPHY BY
DAN BURN-FORTI

EDITED BY
NATASHA BERNAL

Right: Walter Riddell
harvesting juniper
berries to make gin

COVID-19 HAS CREATED UNPRECEDENTED TURMOIL IN THE jobs market and for many, has completely upended how and where we earn a living. Millions of people around the world are being forced to re-evaluate their careers and map out their futures again. Some industries aren't hiring anyone at all. So why not try something completely different? We all fantasise about one day waking up and quitting our jobs to pursue an exciting and life-changing dream project. These people did exactly that. From a financier turned alpaca farmer to a marketing specialist who developed a taste for ice-cream, professionals at the peak of their careers decided, sometimes by choice and other times because they had to, that it was time to bet on themselves. At pivotal times in their careers – and even during the peak of the coronavirus pandemic – they decided to leave city life behind and completely reinvent themselves to find a path to their dream jobs. The secret to their success is simple: find a good idea and the rest will follow.

CAREER
PIVOT

I ditched a career at Morgan Stanley to live in a bog

WALTER RIDDELL

THE MORGAN STANLEY
INVESTMENT BANKER
WHO TRADED IN
HIS DESK JOB TO CLIMB
JUNIPER TREES AND
RUN A GIN DISTILLERY

'I now spend my days one minute up juniper trees cutting down branches, and the next doing payroll for human resources'

IN 2012, WALTER RIDDELL WAS running an investment management portfolio worth \$35 billion for Morgan Stanley. Then, one day, he had enough. "I was a very, very stropky 30-year-old. I probably quit five times before, but my colleagues were indulgent enough to make life easy for me to stay. So they were quite used to me saying that I wanted to go and live in a bog." But this time he was serious. He had long juggled working remotely with his office job – but was immensely frustrated. His true destination was an ancestral home in Hepple, which he inherited when his father, Sir John Riddell, died in 2010. "I'd always tried to balance my job with my heart, which was about being in a rural part of the world, with trying to make ends meet financially," he explains. "I had very generous employers that told me that I could have a year and a half taking the foot off the accelerator." But he had no plans to return. His entire family decamped to the countryside, enveloped by the Northumberland National Park.

Riddell had savings, the support of his family, and no clue what to do next. Enter childhood friend and chef Valentine Warner, who was feeling equally restless. "I've known Valentine since I was ten,"

Riddell chuckles. "He taught me to smoke behind the juniper bushes before I knew what the point of juniper was. We built the business through dog walks and late-night conversations."

They decided to launch Hepple Gin in 2014, as a love letter to the place where they both grew up, surrounded by the largest number of naturally growing juniper trees in England – which happen to be the perfect ingredient for gin.

"One of the joys of wild places is that they are not exploited by people," Riddell says "So how can we make it better?" Hepple Gin has a contract with the national park to help preserve juniper.

The gin market is crowded, but Riddell's team of four believe their triple-brewing technique sets them apart. It involves a traditional copper pot (where they mix the Douglas fir, bog myrtle and juniper); a glass vacuum still, where they add flavours like green juniper or lemon; and an extraction machine, where they infuse the root, the needle, the bark and the berry itself into the mixture.

"I now spend my days one minute up juniper trees cutting down branches, and the next doing payroll for HR," he laughs. His home has become a halfway house for expert bartenders and distillers, who



Below: Dirk Mischendahl and one of his responsibly sourced flavours



roam the corridors mixing spirits and making cocktails in the early hours of the morning. “It’s an adjustment.”

Almost nothing of what he learned from Morgan Stanley applies here – except for the attitude, which Riddell describes as “like a fire in the belly. It’s about doing something because no one else will.”

And, if things didn’t work out with gin, Riddell maintains that he would never go back to working in finance. “It’s very important to burn all those plans. I don’t think they would have wanted it and I don’t think I would,” he admits. He believes that every year of being an entrepreneur makes you “about ten times more valuable” and more employable.

“If you are being paid well, there is a chance that you will never be paid well again,” he warns, “but there is a low chance of being unemployable.”

A change in Riddell’s life was what pushed him to go it alone. He believes the coronavirus might be that same trigger for many seeking an excuse for change.

“It’s often something as small as having an accident. I think coronavirus will perhaps trigger a whole new wave of people deciding to do dramatic things that they would otherwise leave to the last years of their life.” **Natasha Bernal**

I left my marketing agency to run an ice-cream van

DIRK MISCHENDAHL

THE MARKETEER AND
CONSULTANT WHO
SWAPPED CORPORATE
TELECONFERENCES
FOR SERVING UP
GOURMET ICE CREAM

DIRK MISCHENDAHL’S 1972 BEDFORD

van was in the Trinity Leeds street food market in 2015 when a man stopped by and began insulting the quality of Northern Bloc’s ice cream. In Italian. “We’d spray painted the van grey and white to show we weren’t some posh, rolling hills ice cream, we were making it on an estate opposite a sex shop and a prison,” says Mischendahl. “We would make the ice cream at night, sell it in the day. We’d forage for sorrel, source the strawberries. But the van was always breaking down and we didn’t really know what we were doing.”

At the time, Mischendahl was still fairly new to the ice-cream business. Two years earlier, he was running the agency Logistik, which he’d founded

Continued >

in 1996. Mischendahl says the police in Leeds still hate him for one of his early events, the 200,000+ person Love Parade dance music event in Roundhay Park which “shut down the city” in July 2000. Over the next 15 years, the agency shifted toward corporate events, training, comms and consultancy for Unilever, Asda, BMW and Marks & Spencer.

It was teleconferencing that made him snap. Logistik had taken on Lloyds Bank’s annual 5,000-person conference. “We had a 98 per cent positive response from delegates,” he says, “but the person from Lloyds said that the telephone conferencing system was a bit echoey. I thought ‘I can’t be dealing with people like this’.” Mischendahl sold his 43 per cent stake and started selling ice cream with Josh Lee, the nephew of a former girlfriend. They were both foodies with an interest in sustainability; Mischendahl had worked on his father’s farm 20 years earlier.

“In the UK, ice cream is still seen as a second-rate dessert and no-one was doing it the way we envisaged it, which was all about the product, the ingredients, bold flavours and how it was presented,” he says. Enter Manolo Imperatori, the opinionated customer who turned out to be a third-generation ice cream maker and World Gelato Championship winner from Civitanova, Italy. He dropped off his CV a week later and has served as Head of New Product Development since the summer of 2015.

Northern Bloc started out in Leeds city centre and food festivals, graduating to Lord’s Cricket Ground and theatres such as the West Yorkshire Playhouse. When Covid hit, Mischendahl recalls how millennial business owners in a nearby converted flax mill were “shell shocked”. His experience of the 2008 recession at Logistik gave him a “toolbox” of advice he could offer, mostly around resilience and agility. The upshot? Adapt to the here and now, but hold off on major decisions until things settle down. “We’ll get through this, we’re a strong brand,” he says, “but even though we source locally, with Brexit, we need Plans A, B, C-1, C-2...” Northern Bloc was able to continue manufacturing throughout 2020 as “theoretically, ice cream is essential”.

“I still want to stay small and keep innovating,” says Mischendahl. “When I did events, I wanted to be the man about town, whereas now I want to make sure the team is having a good time and create a product I’m proud of, a product that I’m having fun with.” **Sophie Charara**



Above: Quidest Sheriff, photographed by WIRED in her native New York

I quit my job as a doctor to fight the mental health crisis

DR QUIDEST SHERIFF'S MEDICAL CAREER suffered a set-back before it had even begun. Days before she was due to take up her place at Rowan University's School of Osteopathic Medicine in New Jersey, she was knocked off her bike. In addition to breaking numerous bones, she suffered a traumatic brain injury. Not that she allowed that to hold her back. There was simply too much at stake.

"I was the first in my family to get to medical school – on both sides – and I'm a minority. I felt I couldn't take a break," she explains. "I started medical school with a sling on my arm and my leg in a boot."

But, after four years of studying, the brain injury was taking its toll. Panic attacks became the norm and, after going through psychological assessments, Sheriff was diagnosed with severe anxiety, depression and post-traumatic stress disorder.

She continued to focus on her medical career, completing her residency and starting in practice in 2017. But her own experience of struggling with her mental health and "hustling" to find a therapist convinced her something needed to be done. Discovering that US doctors are more likely to die by suicide than any other profession – and that female physicians are 400 per cent more likely to take their own lives than their male counterparts – gave her the final push she needed to take decisive action.

In March 2020, the New Jersey medical centre she was working in was forced to temporarily close after a patient tested positive for Covid-19. Having witnessed the impact the pandemic was having in neighbouring New York, and on other medical professionals like herself, Sheriff decided that this was the moment to quit her job completely and do something about it. She set up her own venture, mdundertheradar.com, an online community that focused on

ways of providing mental health support to female physicians.

"It's a free-for-all right now – if you want to talk about your cat, you can talk about your cat – but it's also a community where female physicians can connect," Sheriff says of the site. "But within [it] we can become mentors and educate each other."

Currently, the platform is focused on networking, and is aimed solely at the US market. Sheriff has ambitions to take it global, though, and expanding operations into Europe is next on her growing hit-list.

"I wanted to start with doctors all over the world, but my brother said, 'let's take it slow, you are a one-woman show'," she says. "My research has shown this is not just an issue in America. All over the world there are statistics that show a high suicide rate among physicians and everywhere the story is the same – women [are disproportionately affected]." Sheriff says she has been "bootstrapping" the business up to this point, funding the development of the website from her own savings. Long-term, she remains focused on rolling the platform out across the globe, so has enrolled on the virtual pre-seed accelerator programme run by The Founder Institute.

"I joined the accelerator programme to be able to talk about the business side and the tech side. I'm able to answer the questions I wasn't able to before," she says. "Once my pitching is good enough, I'm going to enter pitch contests."

Sheriff plans to use any cash raised to connect website users with therapists and coaches. Beyond that, she wants art therapy to be incorporated into the site, though stresses it "is going to be a gem for the future". Given the setbacks she has already overcome, she is convinced she will get there.

"Everything is working out for me," she says. "I have a drive and a passion and I'm creating my own career. Hopefully, my story will empower someone else to do the same." **Margaret Taylor**

QUIDEST SHERIFF

THE DOCTOR WHO
STEPPED BACK FROM
THE FRONT LINE
TO SUPPORT MEDICAL
PROFESSIONALS'
MENTAL HEALTH

GOING IT ALONE THE RIGHT WAY

Thinking of striking out on your own? Here's how to avoid the most common mistakes people make

Workplace unhappiness and redundancies during the pandemic inspired more people to start their own businesses in 2020: Companies House reports 397,135 new companies registered from Q2 to Q3.

But according to Startup Genome, 90 per cent of startups fail – with 20 per cent folding in the first year, and half before their fifth birthday. Only 25 per cent make the 15-year mark.

The main reason: 70 per cent of startups scaled prematurely – they did too much, too quickly, and it proved unsustainable.

Besides miscalculating how long it will take to break even, the Association of Independent Professionals and the Self-Employed (IPSE) says one of founders' biggest mistakes is overspending in the early days of their businesses, splurging on things like a company launch, new staff or non-core services. IPSE advises founders to not undercharge customers and to research the rates offered by the competition before pitching for work. Entrepreneurs must keep on top of cashflow and agree on payment terms in advance to survive the pitfalls of growth, especially during a global pandemic.

Sophia Waterfield



I quit Monzo to look after 300 alpacas

PAUL RIPPON

THE CO-FOUNDER
OF FINTECH COMPANY
MONZO, WHO NOW
PREFERS MUCKING
OUT ANIMALS
USING A DIGGER

Below: Paul Rippon
on his farm in
Northumberland

THE STRESS OF MEETING A DEADLINE TO get a banking licence is nothing compared to losing a baby animal during birthing. Paul Rippon should know: he used to juggle work as a co-founder of challenger bank Monzo with running an alpaca farm alongside his wife, Debbie Rippon.

For a while, the two businesses complemented each other; his teamwork and collaboration skills honed at Monzo transferred over to the alpaca business, while the farm offered perspective. “When you have all of the emotional and intellectual stress of something like Monzo, going

back home and shovelling alpaca shit was very welcome indeed,” Rippon says.

But as both businesses grew, Rippon was being pulled in different directions. He initially tried reducing his hours at Monzo and working from home, but he eventually had to pick a job. He said goodbye to Monzo in November 2019, aged 48, and swapped his fintech co-founders for 300 alpacas (plus 30 goats, 13 chickens, eight sheep, five cats and two donkeys).

Rippon’s pivot from financial services to alpacas had its roots in the early 2000s, when he and Debbie watched a



travel programme in which presenter Michael Palin visited an alpaca farm. The pair became enamoured with the animals and, in 2006, when Paul was offered a job at Northern Rock in Newcastle, far from their Northamptonshire home, Debbie agreed to the move – on the condition she would get three alpacas.

A year later, the financial crisis hit, and Rippon worked on the nationalisation and restructuring of Northern Rock until 2011. In 2014, he was approached by Anne Boden to build Starling Bank, but after a “difference of opinion”, Rippon was part of a group that left to form rival bank Monzo under Tom Blomfield, then CEO.

While all this was happening, Debbie was building up the alpaca business, Barnacre Alpacas. It wasn’t always easy: “We bought a little caravan, put it on the hill, and then we got introduced to the Northumberland winds,” he says. “The winds hit the caravan where we put all our prized possessions, it rolled down the hill and exploded.” They later moved to their current base in the Tyne Valley.

Once Rippon had made his decision to leave Monzo, he knew he had to get the news out quickly before it spread of its own accord. After first texting some board members, he composed a Slack message – complete with emojis and gifs – informing everyone of his decision to step down.

He describes his priorities in his final months as “people, things and a party”. He arranged one-to-one chats with Monzo employees who came to him for advice, and nominated people to take over the tasks he was usually responsible for. Finally, he threw a party: shuffleboard and pizza at a venue near Monzo’s Shoreditch HQ.

Now, his workdays involve feeding animals, looking after the land and mucking out – Rippon’s favourite job, as it means he gets to use his digger. The farm also runs walk-and-talk sessions and lets out holiday cottages for visitors (when permitted), as well as offering livery services to space-strapped alpaca fans.

Rippon’s advice for others looking to leave their city career for something new is to “hope it succeeds, but plan in case it doesn’t”. He suggests trialling an idea for a business on the side of a job, for example by setting up an Etsy shop or starting a YouTube channel, to test the waters.

Rippon has also started working with new banking project. He joined Newcastle-based GBB, which aims to provide loans for property development, as non-executive chair in summer 2020. He planned to work one day a week with GBB but admits that he initially struggled to manage his time, spending too many hours away from farm business. Debbie took the opportunity to grow the herd: Barnacre’s newest resident is Ava the horse. **Victoria Turk**

REINVENT YOURSELF

HOW LOSING YOUR JOB CAN START A NEW CAREER

Redundancies have been the hallmark of 2020, but an ending can also be a bright beginning, if you approach it the right way, explains author Eleanor Tweddell

After a year during which uncertainty and disruption became the new normal, opportunities now lie in the ashes of a global pandemic. Over 500,000 people were made redundant in 2020, according to official UK government figures published in December. For many this is the moment to question everything, career choices especially, and follow a new path. Beyond the grief and the shock of losing a job, there is a chance for reinvention.

I was made redundant in 2017. It wasn’t the best moment of my life, but it created space to ask myself “what am I doing?” and “what do I really want?”. The need to earn money meant that I took one step into freelancing, but my goal of creating a business became a work in progress.

Those of us that find themselves in the same difficult position should reflect on everything in the past, good and bad, to open up their minds to what an “ideal tomorrow” could look like. The things that give joy, that come easy, that matter, can become the foundations to start

something new. They serve as a swift reminder of what has been achieved, and what can be accomplished again, and are a confidence boost that is needed at a time of much self-doubt.

Finding your strengths, interests and opportunities can pave the way to a new career. Away from the shackles of a job title you can discover many hidden talents. A recent client found he could take a spreadsheet and create visuals that told a clear story. He assumed everyone could do that, but he was wrong. He now works with small businesses preparing funding pitches. What one can find easy, another will find so hard they will pay to take the pain away.

Changing careers is a game played in the mind. Your inner voice may say “you can’t do that” or “you aren’t good enough”. But with a plan, it becomes “I don’t know, but I’ll learn” or “I may fail, but I’ll try”. That’s where opportunity lies.

Losing a job creates a choice of what to do next. We’ve spent months dealing with uncertainty and loss, now is the time to create a future that doesn’t just give us what we need, but what we want. **Eleanor Tweddell is author of *Why Losing Your Job Could be the Best Thing That Ever Happened to You***





FIRM UP YOUR CV WITH SOFT SKILLS

Recruiters aren't only looking for hard experience – soft skills such as creativity and emotional intelligence make for more attractive candidates.

According to the Bank of England, the pandemic's impact on the economy will drive the rate of unemployment to peak at 7.5 per cent between April to June 2021. In anticipation of this, the majority of people in the UK (61 per cent) would accept a role in a different sector and focus, according to LinkedIn's Workforce Confidence Index.

But how can job seekers get these roles without experience? According to the social media network, it's all about soft skills.

"Emotional intelligence, collaboration and teamwork are highly valued," explains Janine Chamberlin, senior director at LinkedIn. "[They] help people be great at their job and are transferable."

Creativity, persuasion, collaboration, adaptability and emotional intelligence are in demand, but it's key to have practical examples of these – and outcomes – to stand out says Chamberlin. "This could include how you have managed, supported, coached or mentored team members, planned events, collaborated with other functions or managed difficult conversations.

Sophia Waterfield

CHANGING GEAR

I slammed the brakes on London life to become an adventurer

SIAN SYKES WAS IN HER EARLY 30S AND A project director for advertising firm J. Walter Thompson (now Wunderman Thompson) when she decided to change her life. After some soul searching in her home region of Snowdonia, Wales, she found it harder to go back to the 18-hour days and her corporate life in the capital.

"When I was back home in Wales, I felt really fulfilled," explains Sykes. "I found it quite a hard transition going back into a concrete jungle and a fast-paced environment because I'd been used to big open spaces, the freedom to play."

That's why, in 2013, she slammed the breaks on her corporate career. "I just wanted to feel more fulfilled, and to have a better work-life balance and to reconnect with nature," she says. "I had gone through the motions of chasing a very successful career – and suddenly I lost sight of what I was all about."

Sykes began to take more time out from her London life and started to retrain for a career in the great outdoors, quickly achieving the highest National Mountain Leader qualification. "I'm qualified to lead expeditions all over the world," she says.

She set up Psyched Paddleboarding, based on the island of Anglesey, in 2014, and started to provide standup paddleboarding experiences. These can include leading groups of people along the beach of the Menai Strait, where they can see phosphorescent plankton in the water, and Snowdonia – which has been awarded dark sky status by the International Dark-Sky Association due to low levels of light pollution – to see shooting stars.

It took the paddleboarder a couple of years to get the business off the ground, but now she is in growth mode. "My plan

is securing bigger premises [due to open by Spring 2021]," she says. "I absolutely love operating in Anglesey but I'm [also] taking people on expeditions."

This "giant leap of faith" was influenced by Sykes' drive, but also her trust in herself. "It was listening to this deep yearning inside me, this real gut-wrenching feeling of knowing [what I wanted to do]," she muses. "To me, there was no such thing as failure. I worked at it because I was in charge of my own destiny."

Like many business owners, Sykes has faced challenges due to the coronavirus. Typically, her busiest time is between April and October, but lockdown meant that people were unable to travel.

"It was the first time in my life that things were out of my control. It was a huge learning experience. I was at the mercy of the government," she says.

During lockdown she rediscovered foraging and cooking, and started to make her own natural cleaning products and toiletries, which "was really rewarding."

Luckily, her business had a solid financial foundation and, while she worked a very short season, Sykes says that there was a huge surge in people wanting staycations. And, like a nod to the start of her journey, she now catered for people who had undergone lockdown in London, and who longed for the outdoors. "I got a real joy from taking out groups onto the water because there's a lot of people from cities. All they had was this longing to connect with nature and forget about what was happening in the news. Going out on the water has been really good for boosting people's well-being, and I feel really delighted to be a part of that." **Sophia Waterfield**

SIAN SYKES

THE ADVERTISING PROJECT
DIRECTOR WHO GAVE UP
A 15-YEAR CAREER IN THE
CONCRETE JUNGLE TO
RECONNECT WITH NATURE

Right: Sian Sykes
takes a meditative
paddleboard
trip near Anglesey



|
In 2020, the global
reusable water bottle
market was worth \$8.75
billion, and is projected
to be as much as
\$11 billion by 2025
|



T

here's a moment in Pixar's post-apocalyptic opus, *Wall-E*, where our titular hero saves a Spork from the skyscrapers of landfill – it's a throwaway moment in every sense, but with 40 billion single-use utensils wasted just in the US each year, and six trillion items of plastic waste now drifting in the world's oceans, it's one to be taken seriously. Enter Pebble, a go-anywhere cutlery set made from

recyclable anodised titanium-coated steel and recycled old compact discs (remember those?). This 175g set includes a folding knife, fork, spoon, straw and chopsticks, all neatly stowed in a case that clips to your backpack. They're full sized, sustainable, dishwasher-safe and infinitely more enjoyable to eat with than any compostable or bamboo alternative. *Pebble Triple Pack, £49 [otherware.co](https://www.otherware.co)*



SUSTAIN

| Mining natural diamonds is incredibly destructive – an estimated 250 tonnes of earth has to be excavated per diamond |

From funding civil wars to inhumane working conditions and environmental damage, traditionally mined diamonds should be the sort of “Girls’ Best Friend” that gets ghosted and unfollowed.

Enter Dale Vince, founder of green energy supplier Ecotricity, who has created what is claimed to be the world’s first zero-impact, carbon-negative diamonds at his “sky-mining facility”

in Stroud. Above are eight of these lab-grown stones, each accredited by the International Gemological Institute and with the same chemical and physical properties as mined diamonds. Vince estimates his venture will produce a minimum of 200 carats per month.

Synthetic diamonds have existed since 1954, and several brands including Lark & Berry and Brilliant Earth offer complete

collections, but by using only renewable energy, carbon and rainwater, these Skydiamonds are by far the most sustainable.

They’re created using chemical vapour deposition, where a microscopic diamond “seed” is placed in a chamber filled with carbon enriched gas, and then heated to around 1,500°C. This forces the carbon atoms in the gas to stick to the seed, “growing” you a brand new diamond. etbc.skydiamond.com

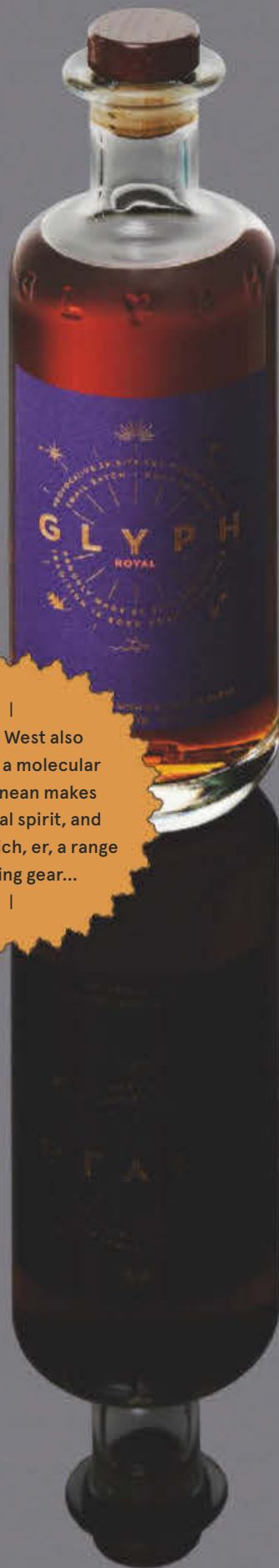
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2020 report commissioned by C&C Group found that the drinks industry is lagging when it comes to sustainability. Glass recycling rates stubbornly remain less than 50 per cent, and moves to reduce plastic packaging have been the result of pressure from green-minded consumers, rather than forward thinking on the part of manufacturers. But there are brands propping up the average with innovative

products and futuristic manufacturing methods that bring a welcome slug of sustainability without compromising on either quality or drinkability.

Leading the charge is San Francisco-based startup Endless West. They've created an entire range of lab-made molecular whisky (*Glyph Royal*, \$29.99 endlesswest.com), without the need for ageing or barrel storage. They claim to

| Endless West also produces a molecular sake, Mc'nean makes a botanical spirit, and Bruichladdich, er, a range of cycling gear... |



SUSTAINABLE SPIRITS

DRINK

|
The E6PR (Eco Six Pack Ring) is fully compostable, so your can-carrier will help grow the hops for your next beer. e6pr.com
|

have identified the molecules in traditional spirits responsible for flavour, aroma, mouthfeel and colour, and then looked to nature for alternatives from plants, fruits and yeasts. All these molecules are then blended with neutral grain alcohol and bottled. Traditionalists will no doubt scoff, but it uses significantly less carbon, land and water – and still comes in at 46 per cent proof.

If you're not quite ready to embrace molecular approximations, Nc'nean's Organic Single Malt Whisky (£47.95 ncnean.com) is made in a distillery powered by 100 per cent renewable energy – the copper pots are heated using a biomass boiler – and is the first UK spirit to use 100 per cent recycled clear glass, which reduces the bottle's carbon footprint by 40 per cent.

Islay-based Bruichladdich (*The Classic Laddie*, £39 bruichladdich.com) has become the first whisky and gin distillery in Europe to become a certified B Corporation. This sought-after private certification requires businesses to be accountable across customers, community, workers, suppliers and the environment and is a solid indicator they're doing more than just greenwashing.

Bruichladdich sources 100 per cent of its barley requirement from Scotland, with 42 per cent from Islay itself, and it has removed single-use plastic from all its sites, while its glass bottles, tins and packaging are all recyclable. The excess heat from the stills is used to warm the offices and visitor centre, and innovations ahead include plans to use wave power to achieve net zero carbon by 2025.

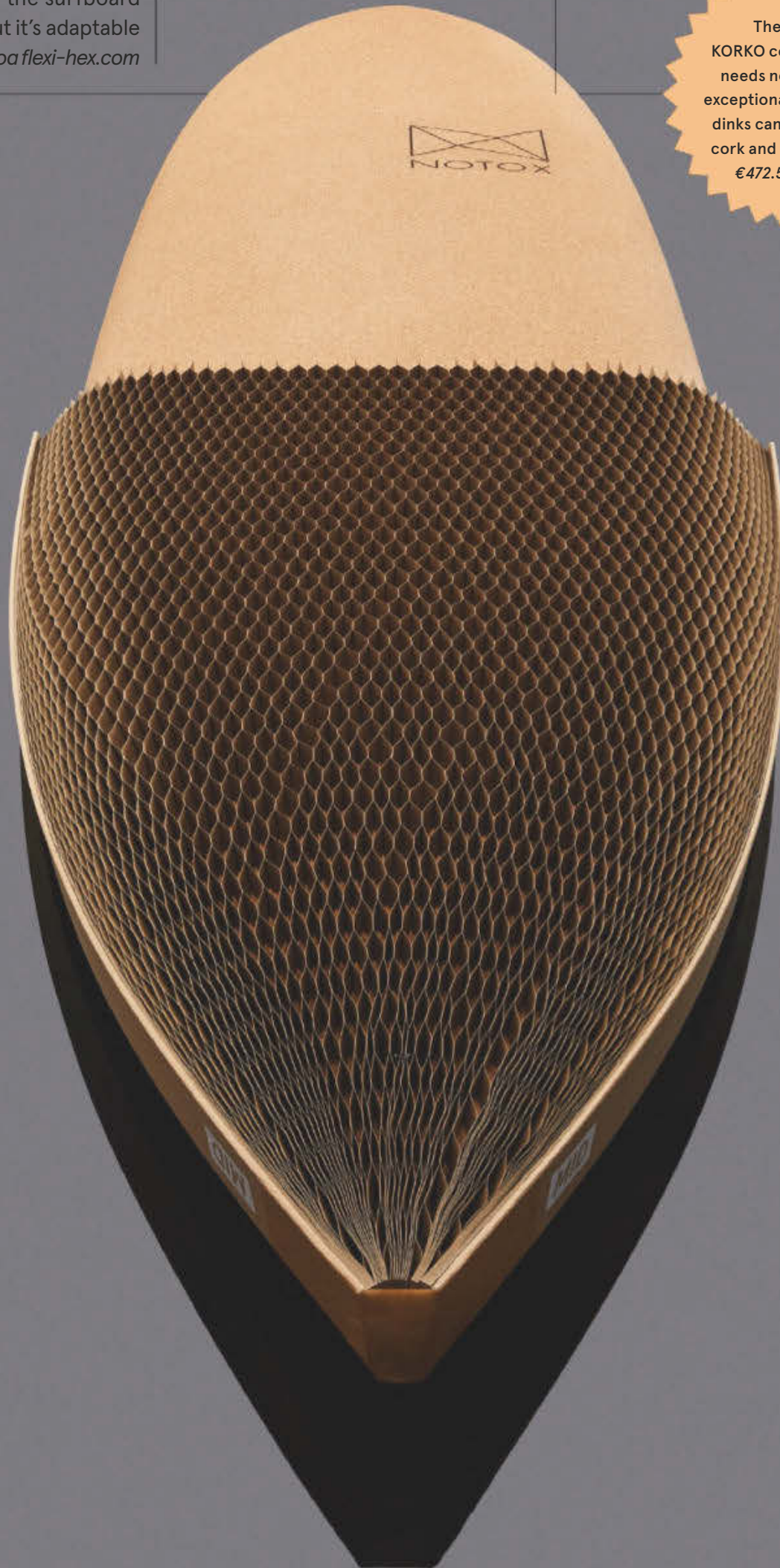
Elsewhere, waste from Nc'nean's distillation process is fed to the local cattle, while The Discarded Spirit Co. (discardedspirits.com) is using banana skins – usually dumped by the fruit industry – to make its Caribbean rum. (The rum is also a rescued byproduct, typically used to flavour whisky casks before maturation.) It has also developed a fruity Vermouth infused with Cascara, a coffee bean leftover that's usually destined for landfill.



|
Compared to traditional brewing, making Freestar zero-alcohol beer emits 90 per cent less CO₂ and uses 80 per cent less water and energy. freestar.co
|

Flexi-Hex is an antidote to packaging waste. It's plastic-free and is made using recycled cardboard – which produces 73 per cent less air pollution than using new paper – while its hexagonal cells provide incredible strength-to-weight performance. It was created to strip single-use plastics from the surfboard industry supply chain, but it's adaptable for almost any product. *£poa flexi-hex.com*

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The NOTOX
KORKO cork surfboard
needs no wax, offers
exceptional grip, and any
dinks can be filled with
cork and sanded. From
€472.50 *notox.fr*
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LIFESTYLE

Two billion pairs of jeans are produced globally each year, requiring around 1.4 million tonnes of raw cotton. According to a study by Levi Strauss & Co, producing one pair of its 501s requires 3,781 litres of H₂O. Not a particularly flattering statistic when over ten per cent of the world's population currently has no access to clean water. Add chemical treatments, carcinogenic dyes, washing, rinsing and finishing, and you've got an industry that's anything but sustainable.

But technology is making it easier to find the right shade of green blue jeans.

Based in Vietnam, Saitex (*sai-tex.com*) is a denim manufacturing plant producing 20,000 pairs of jeans a day, and while that doesn't sound especially eco, it's the first Asian factory to join B Corporation, and represents the easiest route to buying better jeans. Instead of 80 litres, each pair of jeans uses 1.5 litres of water during the rinsing process, saving in total around 430 million litres per year. Saitex recycles 98 per cent of the water it uses, lasers have replaced traditional stone washing and sandblasting, and by air drying, energy use is cut by 85 per cent. It has even started producing building blocks and tiles for low-income housing projects using waste materials. Current brands working with Saitex for their denim include Edwin, Gap, Paul Smith and Everlane.

Meanwhile, Wrangler has developed Indigood, a dying process that uses foam to eliminate the need for water in the process, and has cut energy waste by 60 per cent (1: *Indigood Texas Authentic Straight*, £75 *wrangler.eu*). Wrangler is also starting to make jeans with a percentage of recycled yarn, something that Replay has also adopted with the Hyperflex Bio range which combines organic cotton, recycled fabric and recycled PET bottles for eco stretch (3: *Hyperflex Bio Black Stretch Denim*, £150 *replayjeans.com*).

Like Replay, Italian manufacturer Candiani has been striving to find a less thirsty way to make jeans. Its N-Green jeans start with certified organic cotton and are dyed using Kitotex, an innovation



made from recycling shrimp shells from the food industry which, combined with Indigo Juice, another innovative method for achieving vintage/faded looking jeans without multiple washes, requires a claimed 75 per cent less water and 65 per cent fewer chemicals per pair of strides (2: *Selvedge Reserve New Buck DBL*, €280 *candianidenim.store*). Candiani has also developed Coreva Denim, the first biode-

gradable, naturally sourced stretch denim, derived from natural rubber.

And as for Levi's, it has been collaborating with re:newcell (*renewcell.com*) to introduce a substance called Circulose into the manufacturing loop. This material is made in a similar way to recycling paper, but the resulting cotton fibre, created using old jeans offcuts, makes up 50 per cent of the new pair.

A

s we highlighted earlier, cardboard and cork can combine beautifully to keep your leisure activities on the greenest path, but that impact is a drop in the ocean compared to the effect business and construction has on our resources.

The construction sector is the largest user of raw materials in the UK, producing the biggest waste stream – around 100 million tonnes according to WRAP, the

Waste and Resources Action Programme which works closely with governments, businesses and communities to accelerate the move to a sustainable economy. And while much building rubble is broken down for reuse as aggregates, Scottish startup Kenoteq (kenoteq.com) is turning some back into a low-carbon brick that behaves just like a typical clay brick, but which also brings added benefits.



|
The Serpentine
Pavilion 2021 will use
Kenoteq bricks in a green
mixed-materials design by
South African architects
Counterspace
|

MATERIALS

Invented by engineering professor Gabriela Medero, manufacturing the K-Briq creates less than a tenth of the carbon emissions of a standard brick, but has double the insulation properties of cement and uses 90 per cent inert construction waste. It doesn't need to be fired – it's held together by a binding agent, so there's no energy used to bake it in a kiln – and by adding recycled pigment,

you can specify it in any colour you like.

At the other end of the construction spectrum is Newtab-22 (*newtab-22.com*), a London design studio experimenting with waste from the seafood industry. According to their research, seven million tonnes of seashells from the food sector are discarded annually, most of which are destined for landfill. In response, they've used these unwanted shells to create Sea Stone, an all-natural, non-toxic, cement-like material. It's early days, but we're more than happy to shuck a few more oysters in the pursuit of the ultimate in sustainable building materials.

And finally, some news for businesses still struggling with the concept of the paperless office. The 2.85m-wide Epson PaperLab A-8000 (*epson.co.uk*) is the world's first in-office paper recycler – it can transform your waste paper into new paper, on site, with almost no water.

It requires your waste paper to be flat – sorry, compulsive scrunchers – but once fed into the machine, Dry Fibre technology finely shreds the sheets, colourants are removed and a binding agent is added before the fibres are deposited in a layer and pressed and cut into new paper. It can produce up to 720 sheets per hour in A3 or A4, in a variety of finish and colour options, in weights from 150gsm to 240gsm.

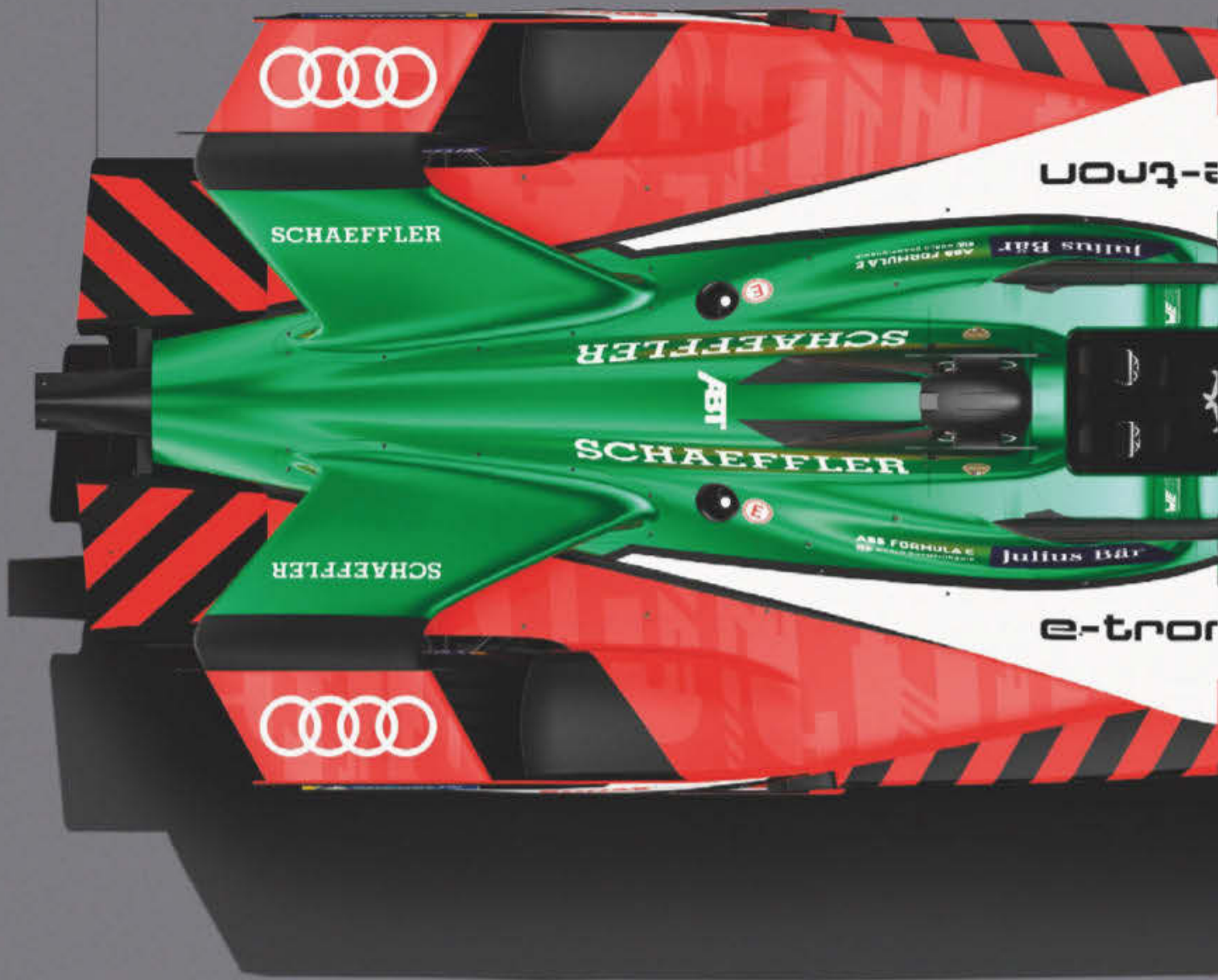
Recycled paper produces 73 per cent less air pollution than paper that has been manufactured using new raw materials



EPSON PAPERLAB A-8000



AUTOMOTIVE



Sadly, the FE07 could be the last electric race car Audi produces, as it announced it would be withdrawing from Formula E after the 2020-21 championship. Fortunately, it's packing in a last lap that's full of innovative electric upgrades that will eventually filter through to its road-going offerings. While many parts of a Formula E car are strictly

dictated by championship rules, teams are permitted to deploy their own electric powertrain, power management and regenerative braking tech. Developed by the Audi Sport division, the FE07 has an all-new electric powertrain, the MGU05. An electric one-speed drivetrain with an internal rotor, external magnets, a highly efficient cooling system and six

electrical phases, it weighs just 35kg and delivers a blistering 0-100kph in 2.8 seconds and a top speed of 240kph. If you compare the MGU05 with an internal combustion engine delivering a comparable power output of 250kW, this electric version is twice as efficient, not to mention that its petrol equivalent would weigh approximately 340kg more. *audi.com*

|
The Audi E-Tron
FE07 can be temporarily
boosted to 285kW (around
382hp) for driving
in "Attack Mode"
|



As the vast majority of watches are made from steel, a substance that can be recycled multiple times without any reduction in quality, you might think there is not much to be done in the way of making them more sustainable or ecologically friendly. Aside from avoiding rare materials such as tantalum, which can be associated with questionable mining practices, there are, in fact, a number of options to consider.

Swatch has its new “Bioreloaded” watches made from bio-sourced materials extracted from the seeds of the castor plant, and includes pieces from its SISTEM51 range featuring automatic movements comprising just 51 components. The self-winding, £124 WAKTU51 has an exceptional 90 hours of power reserve, and even its packaging, made of paper foam, a material based on potato and tapioca starch that can be injection moulded, is fully biodegradable and can be recycled like paper or composted.

Meanwhile, Breitling’s Superocean Heritage ‘57 Outerknown range has been launched with a sustainable

NATO strap collection that uses ECONYL yarn. Made from recycled nylon waste pulled from the ocean, including discarded or lost fishing nets, it means the straps are not only recycled, but also recyclable.

Finally, the new Tom Ford 002 Ocean Plastic watch manages to meld an anti-pollution stance with TF’s trademark pared-back

aesthetics. The timepiece has a case and woven strap that are both made entirely from recycled plastic rescued from the ocean – and its packaging is recyclable. The 40mm quartz-powered watch features a stainless-steel caseback with a black DLC coating, a matte-black dial with lumed numerals, and 100 metres of water resistance. £895 tomford.co.uk



|
The designers estimate that each 002 has removed the equivalent of 32 plastic bottles from floating around in the ocean
|

Ten years on from its first all-electric, the i3, the iX is BMW's new flagship EV. Sporting the fifth generation of BMW's eDrive with its two electric motors providing more than 500hp, the iX can go from 0 to 100kph in under five seconds and has a range of almost 600km, which should allay any anxiety fossil-fanatics might still harbour. DC fast-charging at up to

200kW yields more than 120km of extra range in just ten minutes, and the battery can be charged from 10 to 80 per cent in under 40 minutes.

But, crucially, the iX repeats what made the i3 such a compelling early EV as, like its predecessor, this SUV has been designed from the ground up to be all-electric. It doesn't use any existing architecture from BMW

and, as a result, weight savings can be designed in from the beginning. Plus, with additional nods to sustainability, natural and recycled materials have been employed throughout, and particularly in the interior. Even the vehicle's 100kWh battery has a high recycling rate, while the power used to produce the battery itself is from renewable sources. *£tbc bmw.co.uk*

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The carbon emissions from an electric vehicle are around 17 to 30 per cent lower than driving a petrol or diesel car
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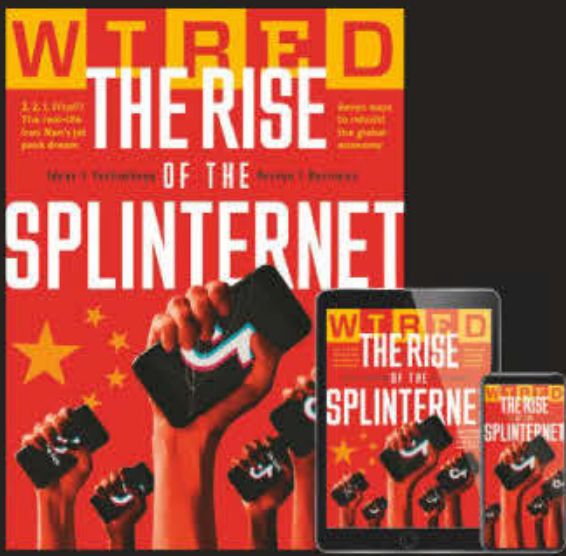


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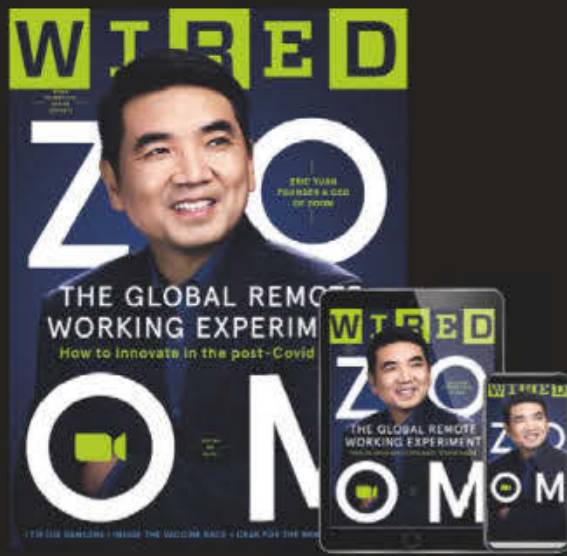
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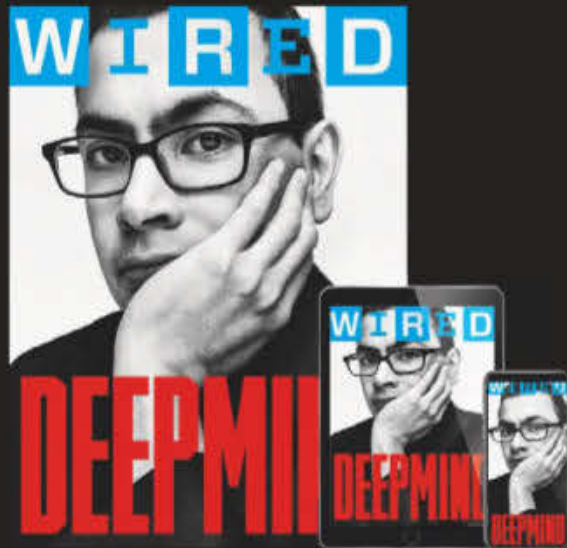
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In 2021, innovative approaches to healthcare provision must bring together new operating models and technology to deliver a fundamentally different patient experience.

One of the areas undergoing rapid change is telehealth. We all know how it should work: you open an app, tap a couple of buttons and get seamlessly connected to a medical expert who can make an accurate diagnosis based on what they can see on a high-quality video feed, as well as having full access to your medical history. But this is rarely the case. The old approach to telehealth is still hampered by sluggish technology, inaccurate artificial intelligence systems and siloed data that doesn't help patients or clinicians fully understand what's going on.

From a more joined-up approach to patient data, to improving remote access to healthcare professionals from across the ecosystem, the technical barriers that used to restrict access to care are finally tumbling down – and HealthHero is leading the charge.

Founded in 2019 and launched to market in August 2020, HealthHero is now the largest telehealth provider in Europe with operations in Germany, Ireland and the United Kingdom, serving more than 20 million people and 1,000 businesses. Through fast, organic growth, strategic acquisitions and an innovative approach to patient care, HealthHero is out to fix an industry that has promised so much but has yet to deliver on patient expectations.

The service provides 24/7 access to GPs as well as experts in mental health, musculoskeletal issues and a range of experienced consultants who can focus on specific areas of care – all remotely and all at the touch of a button. HealthHero brings together human expertise and digital convenience, providing remote access to doctors and expert clinicians directly to patients, insurance-policy holders

and employees, connecting people with a real doctor either by phone, online or through the app – and unlike other providers, HealthHero doesn't claim to replace doctors with an AI.

For physicians, the platform enables them to work flexibly on a platform that is easy to use and only requires small time commitments. For patients, it offers full problem resolution – often an issue with telehealth services that can only make suggestions, rather than deliver a clear diagnosis and treatment

Before the pandemic, just one per cent of consultations were done digitally. HealthHero believes 70 to 80 per cent could be done remotely

Telehealth is how we will meet the challenge of patient care in a pandemic

Healthcare providers across the private and public sectors are scrambling to widen and improve access to doctors and address the gaps thrown into relief by the Covid-19 crisis

plan. This is made possible by a unified and integrated database of patient information that includes data from hospitals, pharmacies and diagnostic centres. The aim is to turn telehealth from yet another silo into a comprehensive digital healthcare platform.

Before the pandemic, just one per cent of consultations were done digitally. Now, that number is starting to surge upwards. HealthHero believes that, of the four billion doctor-patient consultations that take place in Europe annually, 70 to 80 per cent could be done remotely without compromising on the quality of care and the outcome for patients. Through the course of the pandemic, HealthHero has recorded a 300 per cent increase in demand for remote GP consultations. And what has been necessary during the pandemic will soon become the norm for many people who find digital healthcare easier to access and more convenient without having to sacrifice any quality of care.

HealthHero is essentially a platform that incorporates decades of experience in a range of fields. In December 2020, it acquired Doctorlink, a London-based telehealth platform founded in 2016. Doctorlink has already provided care for 12.5 million patients across the UK and is used in more than 1,500 NHS GP surgeries. In the last nine months



Be it by phone, app or online, HealthHero's telehealth platform can connect patients wherever they are with a real physician for convenient and holistic healthcare

alone, the service reported a 250 per cent increase in its active user base and a 900 per cent increase in video consultations.

As well as Doctorlink, HealthHero has also made strategic acquisitions of established clinical businesses across primary care and mental health services, and has expanded into new markets with the German telehealth specialists Fernarzt, and now the Irish platform MyClinic. This strategy has afforded HealthHero a breadth of expertise and clinical experience across

sectors which, combined with sophisticated digital tools, provides HealthHero with a unique service that is capable of examining each patient as a whole.

It might sound counterintuitive, but the big breakthroughs in telehealth won't necessarily be made through the development of smarter artificial intel-

ligence systems, but through something far more prosaic: improving data transparency. The existing structure for healthcare data – creating silos based on areas of clinical expertise – has largely been replicated by the first wave of telehealth services, and as a result, many of these suffer from only being able to offer one aspect of patient care. HealthHero can provide convenience and holistic healthcare that's impactful for patients and healthcare providers alike by combining all this data and treating the whole patient, while also leveraging digital tools to do so in a more helpful manner, improving accessibility and creating better patient outcomes.

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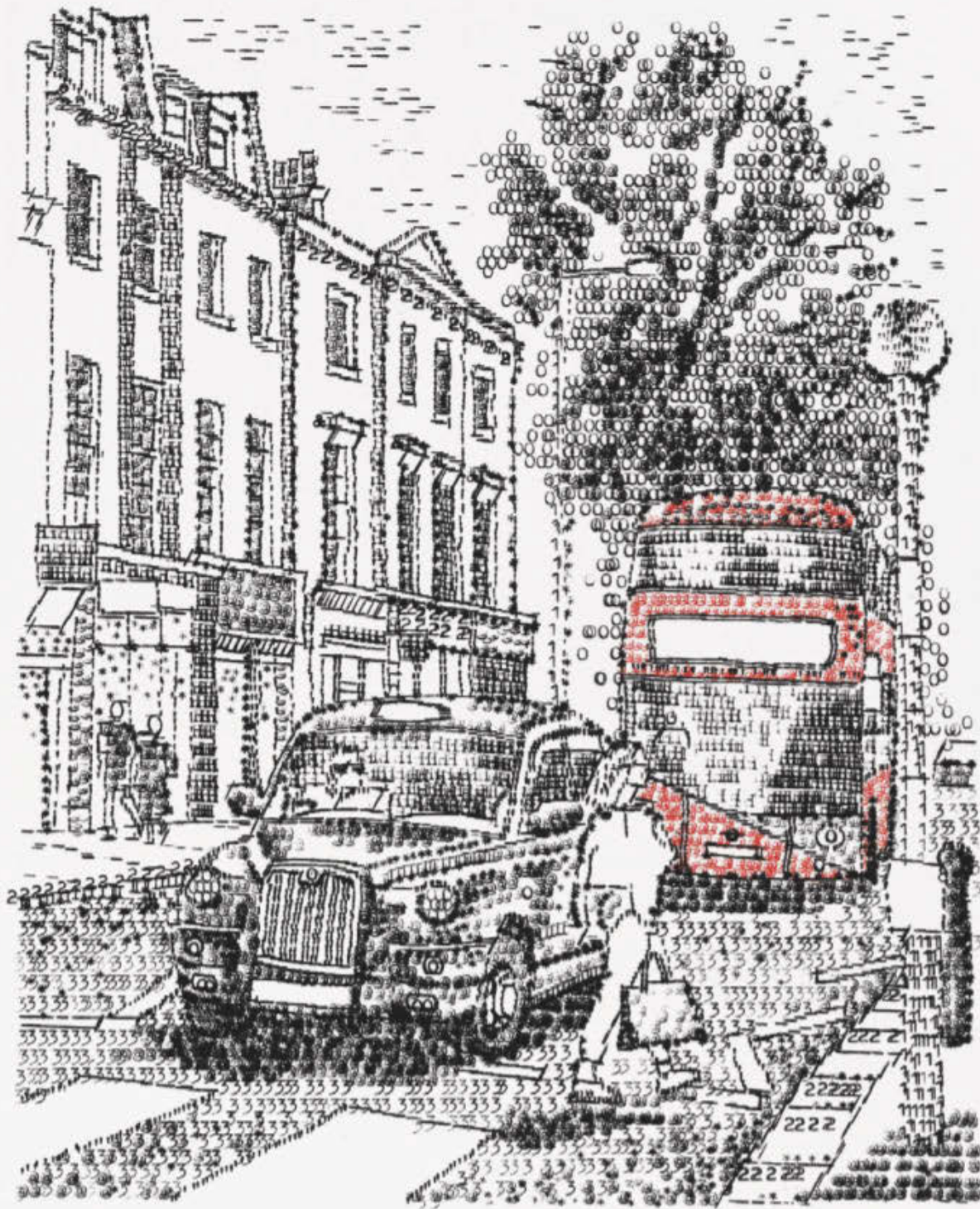


ILLUSTRATION: JAMES COOK. ASSEMBLED FROM THE CHARACTERS, LETTERS AND PUNCTUATION MARKS OF A TYPICAL TYPEWRITER'S 44 KEYS. EACH TAPPED AT VARYING PRESSURES TO ACHIEVE TONAL SHADING. THE IMAGE RESOLVES AT A DISTANCE, WHILE A HIDDEN MESSAGE CAN BE DISCERNED ON CLOSER INSPECTION

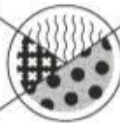
“The idea that banks are going to solve this problem – I don’t get that”

Bill Gates, p66



**“You should start
working on
the hard things,
not just on
the easy things”**

By Greg Williams
Photography:
John Keatley



**In the face of
one of humanity’s
greatest
challenges,
Bill Gates lays
out his plan for
attaining net
zero carbon
emissions.**
Here, he speaks
to WIRED with
optimism and
clarity on what
needs to be
done to achieve it

How to Avoid a Climate Disaster.

In his new book, Bill Gates argues that there are really only two data points that matter when it comes to tackling humankind's existential challenge: 51 billion and zero.

The first is the number of tonnes of greenhouse gases that are typically added to the atmosphere every year. The second is the number we need to arrive at to avoid catastrophe.

While acknowledging that the challenge is daunting, and how we make things, grow things, move around, keep cool and stay warm will all need to fundamentally change, Gates argues that wholesale transformation is possible while maintaining lifestyles in high income countries and continuing to lift billions out of poverty. And he has a plan.

He employs the concept of the “green premium”. Carbon remains cheaper as a source of energy because its negative impacts – or “externalities” – aren’t priced in. Governments subsidise fossil fuels because they are reliable and proven. The green premium is the additional cost of using a green alternative in their stead. In some instances – such as producing electricity using wind turbines or solar energy – it can be zero, depending on the country. In other sectors such as concrete, fertiliser or steel production, it’s enough to deter the use of clean alternatives. While wealthy countries might be able to pay a premium for these zero carbon options, that isn’t currently possible for some fast-growing nations in Asia, Africa and South America. The green premium needs to be so low as to make sense to switch.

Sat at a large conference table wearing a blue pullover, Gates speaks with WIRED in December 2020 from his office overlooking Lake Washington in Seattle. He outlines how a number of different technological breakthroughs, large-scale investment in infrastructure, patient capital, government policy and individual action can have an impact, and provides a roadmap to getting to zero carbon emissions by 2050.

Zero is important: just reducing the carbon we’re putting into the atmosphere simply extends the extremely limited amount of time humankind has until we hit planetary boundaries. Currently, the concentration of carbon dioxide in Earth’s atmosphere is around 414.68 parts per million (ppm) – there is consensus that, once the level reaches 450ppm, it will raise the global temperature above two degrees Celsius, triggering extreme weather events and irreversible, catastrophic change. While some advocates of change suggest that the target should be 2030, Gates believes that’s unrealistic – carbon is too deeply woven into the fabric of everything we do – and could provide a distraction to the more significant goal of zero emissions by 2050.

Why this book and why now?

Bill Gates: “I did a TED Talk in 2010 on climate, and five years later there was the Paris climate talks, and I’d been saying: ‘Hey, how come when they have these meetings, they never talk about R&D?’ They never talked about innovation, and if you looked at the energy R&D budgets of the rich countries, they hadn’t increased at all.

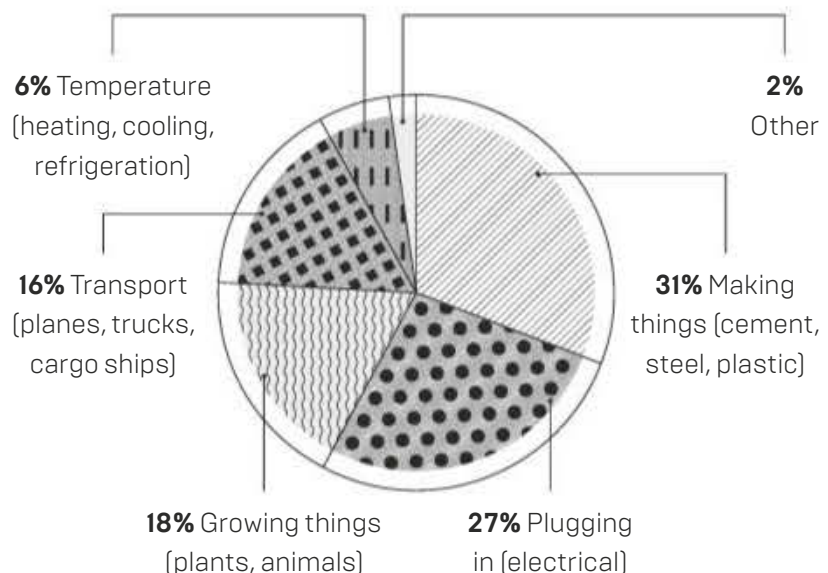
So everybody’s getting together and talking about the short-term reductions, but the only areas you can make short-term reductions are electric cars and using solar and wind for electricity generation. That’s less than 30 per cent of the game – 70 per cent is steel, cement, aviation, land use... People aren’t doing anything about those. If you want to get to a goal, you should start working on the hard things, not just on the easy things. I’m not saying the easy things are easy, they’re just relatively easy.

These nationally determined metrics – the short-term reductions – don’t really tell the story. I’m not saying they should go away – those are good things – but what is the true metric of ‘by 2050 can you get to zero?’

The resonance of the topic [climate change] is very high now, despite the pandemic, which is impressive. But if we don’t have a plan to go with that positive energy it’s going to be very sad. You’re going to get attenuation: people will almost be cynical that we didn’t really get going on the 70 per cent that’s the hardest.

So, that’s why I wrote the book, to suggest that the green premium is a metric that – when you call up India in 2050 and say, ‘Hey, when you’re building new buildings, use this cement, use this steel’ – will determine whether they tell you ‘get lost’, or ‘OK, we’ll pay a slight premium’. If you’ve innovated enough and the green premium is zero, they’ll say, ‘Of course.’”

GLOBAL GREENHOUSE GAS EMISSIONS CAUSED BY HUMANS



Some green premiums – for electricity, for instance – are within reach. Others will involve huge amounts of R&D and investment. How do you think about that?

“The brute force way to solve climate change is to figure out how to do direct air capture, get the cost per tonne down and then just write the cheque. Unfortunately, if you call up Climeworks [the Swiss company that filters CO₂ from the air], its list price is \$600 (£435) a tonne, and they have some government subsidies. So, even if you dream that you can get to \$100 (£72) a tonne, you’ve got 51 billion tonnes of emissions, so that’s a \$5 trillion (£3.6 trillion) a year price tag to brute force climate change.

Only by going into the individual areas and changing the way that, say, you make cement, or the way you power cars to be electric, do you get something that’s under \$100 a tonne. Electric cars are the magic one – as battery volumes go up, charging stations get out there and battery energy density increases to the point that range and charging speed isn’t that much worse [than combustion engines]. Eventually you can say the green premium for passenger cars ten years from now will be about zero.”

Vaccines typically take a decade or more to produce – Covid-19 proved we can accelerate that process, but it took a pandemic to show us what’s possible. How can we communicate the urgency of the climate emergency?

“There is an analogy to the pandemic which is that citizens depend on their governments to understand natural disasters, meteors, climate change and respiratory viruses. These problems are way too complex – individuals aren’t going to study climate models. For the pandemic, the risk was there and the idea of how you orchestrate a testing capacity and make a vaccine should have been there.

After Ebola in 2015, there were a few things done such as the creation of CEPI [The Coalition for Epidemic Preparedness Innovations] along with Wellcome in the UK, ourselves [the Bill and Melinda Gates Foundation] and 12 governments. And we’ve been funding mRNA stuff (mRNA medicines instruct cells in the body to make proteins to fight diseases) for a long time. But, governments have to take complex problems and essentially think through what you have to do. Unfortunately, when it comes to the climate, it’s not like there’s any vaccine-like thing, where there’s a solution and six months from now things are going to feel utterly different.

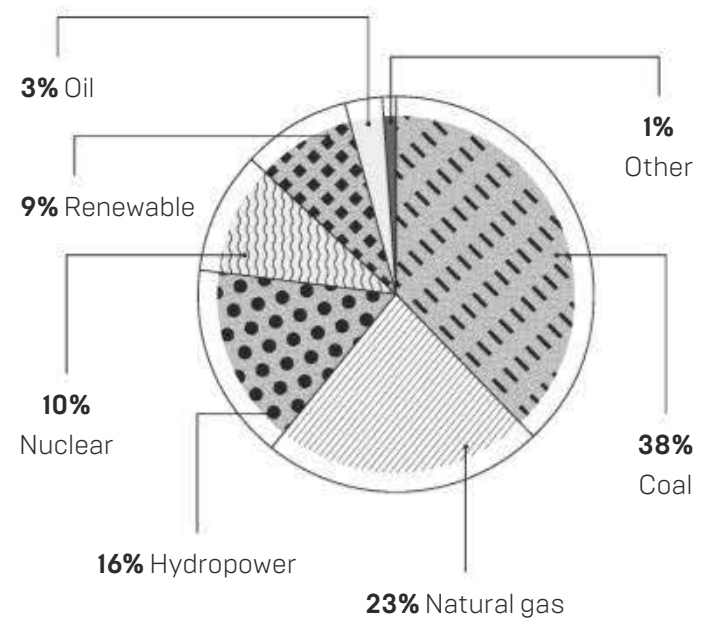
With climate, when you have to replace every steel plant, every cement plant, take the electric grid and make it two and a half times bigger with intermittent sources – this is the entire physical economy. The physical economy is a miracle: it’s taken us since the Industrial Revolution to figure out how to make this stuff so cheap and so reliable that we all just take it for granted. Most people flip that light switch and the miracle of

innovation that allows their lights to turn on 99.99 per cent of the time, they have no idea. It’s so cost-optimised, but now that we have this constraint on it: how quickly can you switch all that around?

So climate is like a pandemic in that governments need to work on behalf of their citizens and anticipate what will happen in the future, but it’s way harder than making a vaccine. If the pandemic had come 20 years ago, we wouldn’t have been able to make that vaccine. If it came ten years from now, with mRNA we’ll be able to make it faster, we’ll be able to scale up more of those vaccines at a cost of \$1 each.

‘Unfortunately, when it comes to the climate, it’s not like there’s any vaccine-like thing’

WORLD’S ELECTRICITY SOURCES



We caught mRNA halfway in its maturity cycle, we hadn’t made a single vaccine. CureVac is developing mRNA-based vaccines designed to prevent malaria infection. Moderna is focused on HIV and other diseases.”

In order to get to net zero by 2050, we’re going to have to innovate at an unprecedented pace. How do we best address that challenge?

“We need to up the supply side of innovation and the demand side for innovation. The supply side has got many components, it’s got your basic energy R&D budget where you just have a bunch of professors or national labs messing around with different ideas, and that’s pre-commercial research. In the US, more than half the federal money spent on biomedical research comes from the \$43 billion a year National Institutes of Health (NIH) budget. Weirdly these energy R&D budgets haven’t had the examination they deserve when it comes to climate events.

Then venture capital has to be willing to take huge risks, and be very patient and orchestrate way more capital than you need for software, microchips or for medicine. That’s because these are big plants and you have to replace a lot, you have to scale these things up so you need to work on the supply side and innovation.

On the demand side, you could put on a big carbon tax but politically it’s difficult – such as when they increased the price of diesel in France – even though economists say that it would be good. In most countries we’ll probably end up with a sector-by-sector approach where we say that, for instance, every building has to have five per cent clean cement, or maybe the highly profitable tech or finance companies pay a premium for buildings.

Everybody mistakenly thinks that the learning curve means that you make something, and then it gets cheaper than you expected. That is true for wind, solar and lithium ion batteries – the learning curves have been phenomenal. But how do you bootstrap the clean aviation fuel learning curve, or clean steel?

There’s a lot of talk that the recovery funds in Europe will get focused on things such as clean hydrogen. But we really need a mechanism to find who in the world has the best ideas about clean steel or clean cement. And the green premium is the metric.”

You had an ambitious aim when you started Microsoft – a computer in every home. What lessons did building and then scaling a company with that impact have that can be applied to getting to net zero?

“I’m amazed at what a nice business software is – you get

‘Somehow, we’ve gotten to this point where climate change has become political, mask wearing has become political’



feedback from your customers and you add features. And I was optimistic: I would invest in things that would take ten years to get done. I tried multiple approaches, so we often had teams that might develop a database in two different ways to see which would succeed. I had to anticipate advances in hardware [that would impact] our software. We spent a lot of R&D money, but we had enough products that were always fairly profitable.

I had a broader view that we were going to develop many types of software – most of our competitors were single-product companies, and we saw ourselves as a software factory independent of word processing or spreadsheets or operating systems. We had a more crazy view that we were going to do every type of software in one company and we had this vision of personal empowerment through software.

We were able to create this research group – Google is the only other company to put money into fundamental research. Because, at first, we all just benefited from what the universities or even Xerox PARC had done that they failed to exploit. We hired specific people from Xerox PARC that helped us with graphics interface, networking and other things, and we almost felt guilty that we needed to get back to this pool of intellect.”

Some policymakers and leaders are aiming at 2030, but you’re fully focused on 2050. Why that time frame?

“In 2050 I’ll be 95 years old and I will be super happy if I live to see the day that we’re anywhere near zero. This is very, very hard, as it requires all countries to get involved. And so the 2050 date was picked as the best case because a lot of things have to work. But if you innovate for ten years, deploy for 20 years, and you create the right incentives through government policy, you can get to zero by 2050. You have to get going now on the hard stuff and you have to admit: do we have even a clue how we’re going to do the hard stuff and find the craziest thinkers?

I’m not smart enough to know all the different ways you might replace cement or steel. You better be searching the entire IQ of humanity globally to find that person or find ten of them and hope that, even if nine are wrong, one will get you there.

I don’t know if that will happen by 2050. If we take the idealism and energy the younger generation has created around this and we make it a priority – Biden has it right up there with the pandemic, European recovery funds have it very high – then, yes it’s doable.

Getting to net zero by 2050 is not going to be easy. So anybody who says, ‘Oh, let’s just get it done in ten years’, I want them to go tour all the Chinese steel and cement plants and tell me what I’m going to see there ten years from now.

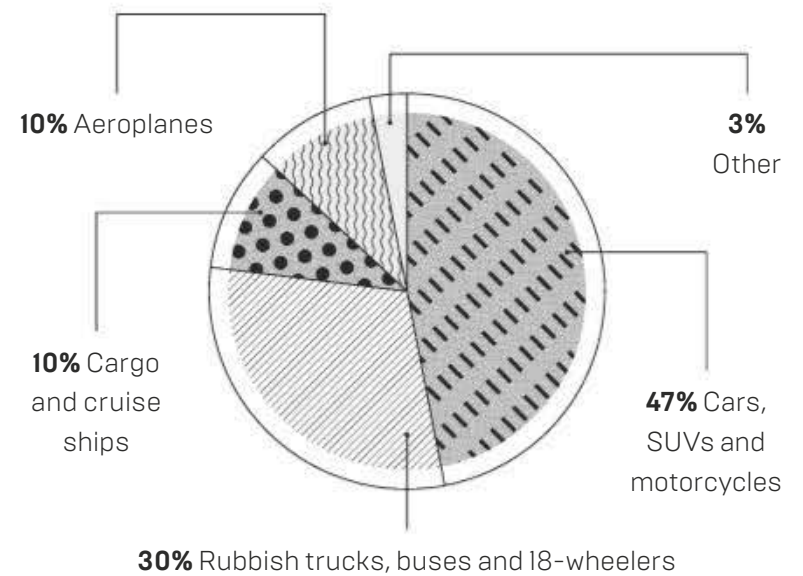
The digital economy has fooled us in terms of how quickly things can change, because you don’t need the reliability and scale, and therefore the capital and the regulations. With software, if it has mistakes it’s not good, but it evolves quickly.”

Institutions deploying capital – banks and pension funds – are going to be crucial in this process. There’s a lot of rhetoric at the moment with businesses claiming to be purpose-driven. How can we best measure the actions large investment funds are making, and how can we keep big organisations honest about their actions?

“Most of that’s all bullshit. The return on a bond for a wind farm is no different than the return on a bond from a natural gas plant, so it’s nonsense. The people who

‘I’m not smart enough to know all the different ways you might replace cement or steel. You better be searching the entire IQ of humanity globally’

GLOBAL TRANSPORTATION EMISSIONS



put money into Breakthrough Energy Ventures [the venture arm of Gates’ organisation Breakthrough Energy that’s working towards net zero], that’s real. The governments that raise their energy R&D budget and manage to spend it well, the near-billion dollars put into TerraPower [Gates’ nuclear company] to see if this fourth-generation fission reactor can be part of the solution... Those things are real.

All this other stuff – like, we’re gonna make companies report their emissions. The idea that some financial metric reporting thing or some degree of divestment – how many tonnes? You’ve got 51 billion tonnes [of CO₂ that needs to be removed]: when you divested, how many of those 51 billion tonnes went away?

You’ve got to *invest*, not *divest*. And the notion that you just happen to own equities or bonds related to the easy things that are already economic, such as solar farms or wind farms... Whenever somebody says there’s something called green finance, I say let’s be numeric here: is the risk premium for clean investing lower than the risk premium for non-green investing? The answer is: just look at the numbers.

The idea that banks are going to solve this problem or that these metrics are going to solve this problem, I don’t get that. Are they going to make the electricity network reliable? Are they gonna come up with sustainable aviation fuel? It’s just disconnected from the problem and allows people to go off and blather as though something’s happening.”

The last couple of weeks have seen the Covid-19 vaccine roll-out begin. Do you think that will increase trust in science, which will impact the urgency to act on the climate crisis?

“Whenever you do innovation like social networks, at first you’re not sure what phenomenon will emerge out of that. I do think the pandemic has helped social networks realise that the First Amendment is nice, but allowing lots of vaccine misinformation is not good for society.

Drawing the line between the crazy ‘all vaccines are bad, everybody will get autism’ versus legitimate [commentary] on people who have allergic reactions is very hard. At first the [social networks] thought ‘we will just let the craziness flow’, but the fact that the wrong stuff is so titillating draws people in.

We hope that this process has accelerated some maturing of the social networks so that the things that get a lot of attention and are really wrong, that these are greatly reduced or put alongside the truth. I don’t know if that will happen, but I have seen it – including conspiracy theories that relate to me – they’re doing a better job of saying, ‘OK, we don’t

BREAKTHROUGHS NEEDED

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Hydrogen that can be produced without emitting carbon,
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Zero-carbon agricultural fertilizer,
- ^

Geothermal energy,
- ^

Grid-scale electricity,
- ^

Next-generation nuclear fission,
- ^

Pumped hydro,
- ^

Electrofuels,
- ^

Carbon capture (both direct air capture and point capture),
- ^

Thermal storage,
- ^

Advanced biofuels,
- ^

Zero-carbon cement,
- ^

Drought- and flood- tolerant food crops,
- ^

Zero carbon alternatives to palm oil,
- ^

Plant- and cell-based meat and dairy
- ^

Underground electricity transmission,
- ^

Coolants that don't contain fluorinated gases
- ^

Zero-carbon plastics,

want ten million people to see that today because it doesn't serve their interests or society's interests'.

People are more educated today than ever and somehow we've gotten to this point where climate change has become political, mask wearing has become political.

For some types of innovation this has been a period where the normal rules don't apply. The idea of 100 companies all working on one disease is insane, because five or six of these vaccines at most, will end up getting used. So you've got 94 companies' efforts that are completely redundant, particularly now.

We still need Johnson & Johnson, AstraZeneca and Novavax, because those [vaccines] are more scalable, cheaper and more thermally stable. But, once we get those five [including Pfizer and Moderna] then we probably don't need any more, because fortunately it turned out it was easier to make a vaccine for this disease than we might have guessed: the first that are proven are working very well."

Science has become politicised in the past few years. We're seeing a transition between administrations in the US, do you think that's going to impact policy as relates to getting to net zero?

"In the Democratic primaries, people were talking about trillions of dollars being spent against climate. Well there's two problems with that: a) that money will never be allocated, and b) spending that scale of money doesn't really connect to the problem, it's more about creating jobs [by doing things such as] insulating homes.

But those homes should use electric heat pumps, and you should get electricity to zero. You must have people who are

in the centre and saying, yes, this is a good goal, but how do you realistically achieve that, and at the minimal price for doing so? You want debate about that, and market-based pricing actually allows a lot of resource choices to be made in a very efficient way. That's why, if you could have a properly done carbon tax, it would be a nice thing, but that's not going to happen in most countries.

So, yes the Biden election is fantastic. He's got climate as one of his top priorities along with the pandemic, he's picked people that know this topic and he's put them not just in specific roles like the Department of Energy, but even people such as Brian Deese to head the National Economic Council. He was the [Obama] White House climate person, and I got to know him when we were doing the Paris climate stuff."

You acknowledge early in the book that you're an imperfect messenger – a rich, white guy some people will accuse of having a god complex. How do you communicate the idea that – forget Bill Gates in all this – it's a problem that all of us have to fix?

"The fact that we need better metrics in this field surprises me. It's a field with a lot of positive energy but without a plan. And so you have to work backwards from zero. If there was some book that had already explained all this, I wouldn't have written it. I can write books about malaria and HIV and diarrhoea. Now, maybe not as many people would read those, but that global health work we do is truly neglected. You can save millions of lives. And it's hard stuff – we don't have an HIV cure yet, but we're trying to use gene therapy and make that super cheap – so there's plenty of interesting work for the Gates Foundation, such as improving agriculture with new types of seeds, and even improving photosynthesis.

This field [climate] as I learned about it, the framing wasn't quite right. I actually resisted the idea that I should choose to speak out. Instead I thought, 'I'll just do a little bit, like that 2010 TED Talk that I did'. And then this field, because people care so much about it, would then mature in terms of its metrics and working on the hard things. When we were talking about the 2015 Paris talks, it makes no sense – why am I at it, saying there should be an R&D section?

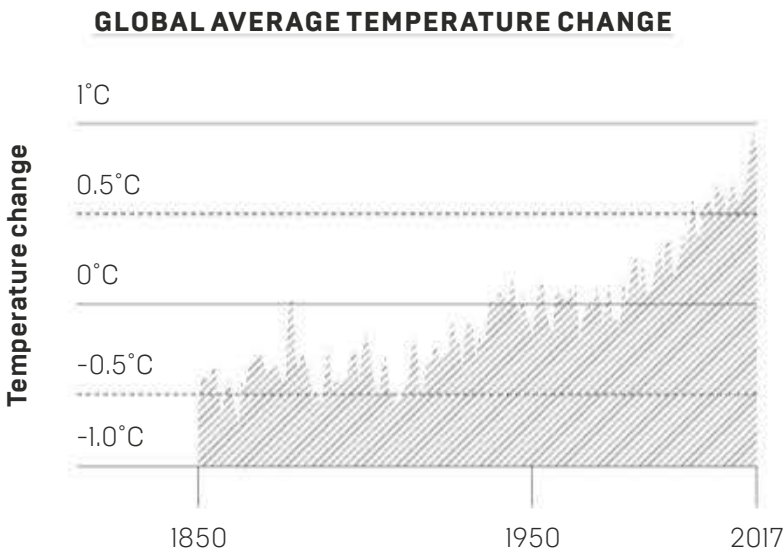
So, I'd say it's strange that the background I have – of systems thinking to drive innovation – brings a slightly richer perspective. OK, not everybody reads Vaclav Smil, not everybody is that numeric. People read articles saying, 'this is the equivalent of 20,000 houses' or, you know, '50,000 cars', and they don't call up the publications involved and say, 'why are you spewing these completely confusing metrics?'

I have this effort to create an open-source model of electricity demand generation that includes weather models, so the countries that have made really aggressive commitments about renewable use can see that their grid is going to start being reliable. Now that the utilities are being told, 'Oh, you have to sign up to these things', you need an open-source model that really shows, do you have enough transmission, storage or non-intermittent sources like nuclear fission or fusion?

The fact that I'm running an open-source model to test whether these aggressive goals are achievable, it blows the mind – why am I funding this model for these electric grids, which is the most obvious thing to do when you look at climate change?"

If you had to bet on a single breakthrough happening in the next decade that really was a game changer, what do you think it would be?

'The idea that banks are going to solve this problem or that these metrics are going to solve this problem, I don't get that'



‘The pandemic helped social networks realise the First Amendment is nice, but allowing lots of vaccine misinformation is not good for society’



DATA SOURCES: BERKELEY EARTH; INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION;
OECD-FAO AGRICULTURAL OUTLOOK 2019; BP STATISTICAL REVIEW OF WORLD ENERGY 2019; BREAKTHROUGH ENERGY

“Well, part of the point of the book is that [we can’t rely on a] single breakthrough, we need artificial meat, we need lithium... But I would say is that if you can get super-cheap green hydrogen, it sits in terms of the industrial economy at the peak. So, if you pencil in ridiculously low-cost hydrogen, then I can tell you how to make clean fertiliser and clean steel, and even clean aviation fuel.

We have to be careful: some scientific miracles like a storage one may never occur. Some people are now talking about super-clean hydrogen. They don’t get how hard it is, and there’s a good chance it will never be possible to make cheap, green hydrogen.

In this space we need about ten breakthroughs before you can really see a path to 2050, but clean hydrogen is higher than most people would expect. And storage miracles, and either fission or fusion. The book is supposed to make you think it’s not like the pandemic vaccine, though.”

Are you optimistic that we can get to net zero by 2050?

“Absolutely. But that’s just my personal bias – I’m an optimistic person. I lived through the digital revolution, where every dream we ever had about computing came true. So, I don’t have proof – but yes, I am optimistic.”

Greg Williams is the editor of WIRED.

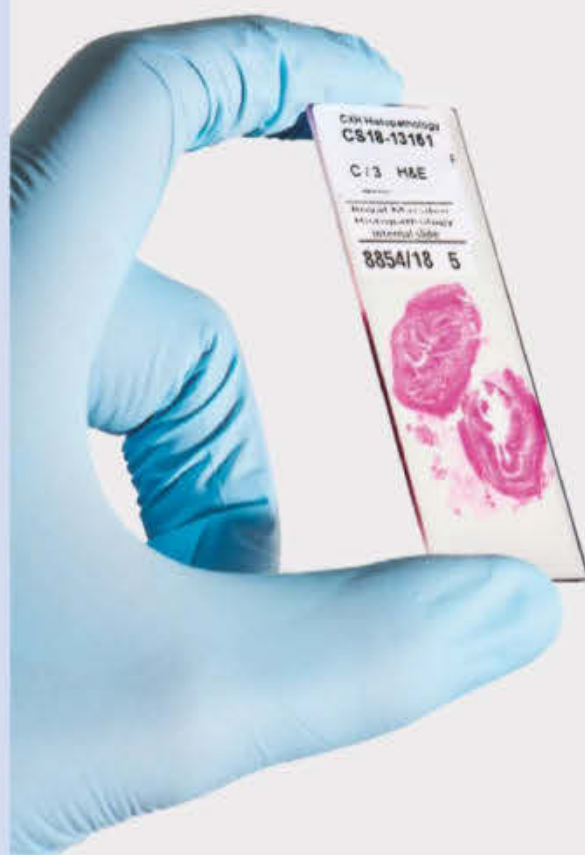
He wrote about DeepMind’s quest to crack protein folding prediction in the September/October 2019 issue.

This conversation has been edited for clarity and brevity

How To Avoid a Climate Disaster: The Solutions We Have and the Breakthroughs We Need by Bill Gates is published by Allen Lane on February 16

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By tightly controlling growing conditions, Infarm can produce fresh crops that are more flavourful and require only a fraction of the usual water

> This mint crop has never seen soil or sunshine: it was grown hydroponically and lit by LEDs

THE FUTURE

> From vertical farms to next-gen aquaculture, seawater irrigation, the end of cow burps and harvesting microbial protein, we explore how we'll be eating in the near future

OF

FOOD

> Photography:
Ériver Hijano

> Guest typeface:
F37 Caslon

A full-page photograph of a man with a beard and short hair, wearing a white lab coat over a black turtleneck. He is standing in a clinical or laboratory setting with light blue cabinets and two large surgical lamps above him. His hands are clasped in front of him. A name tag is visible on his chest.

Time to
grow UP

SAUTO KS
Pulse and Sensation

Seven years ago,
Berlin startup
Infarm was a bedsit
pipedream.

Now its vertical
farms sit in
supermarkets
and restaurants all
over Europe.
But can it move from
salad garnishes for
the wealthy to providing
healthy produce
for the urban masses?

By Sean Williams



THE FUTURE OF FOOD

artenfeld Island, in Berlin's western suburb of Spandau, was once the bellows of Germany's industrial revolution. It hosted Europe's first high-rise factory and, until World War II, helped make Berlin, behind London and New York, the third-largest city on Earth.

Today's Berlin is still a shell of its former self (there are over a hundred cities more populous), and the browbeaten brick buildings that now occupy Gartenfeld Island offer little in the way of grandeur. Flapping in the gloom of a grey November morning in 2020 is a sign which reads, in German, "The Last Days of Humanity".

Yet inside one of these buildings is a company perched at agriculture's avant-garde, part of the startup scene dragging Berlin back to its pioneering roots. In under eight years, Infarm has become a leader in vertical farming, an industry proponents say could help feed the world and address some of the environmental issues associated with traditional agriculture. Its staff wear not the plaid or twill of the field but the black, baggy uniform of the city's hipsters.

Infarm has shipped over a thousand of its "farms" to shops and chefs across Europe (and a few in the US). These units, which look like jumbo vending machines, grow fresh greens and herbs in rows of trays fed by nutrient-rich water and lit by banks of tiny LEDs, each of which is more than ten times brighter than the regular bulb you'd find in your dining room. Shoppers pick the plants straight from the shelf where they're growing.

Gartenfeld Island, however, is home to something more spectacular. Here, in a former Siemens washing machine factory, stand four white, 18-metre-high "grow chambers", controlled by software and served by robots. These are the

company's next generation of vertical farms: fully-automated, modular high-rises it hopes will scale the business to the next level. According to Infarm, each one of these new units uses 95 per cent less water, 99 per cent less space and 75 per cent fewer pesticides than conventional land-based farming. This means higher yields, fresher produce and a smaller carbon footprint.

Agriculture is a £6 trillion global industry that has altered the face and lungs of the Earth for 12,000 years. But, unless we change our food systems, we'll be in trouble. By 2050, the global population will be 9.7 billion, two billion more than today. Fifty-six per cent of us live in cities; by 2050 it will be 70 per cent. If the prosperity of megastates like India and China continues to soar, and our diets remain the same, we will need to double food production without razing the Amazon to do it. That sign on Gartenfeld Island might not be so alarmist.

Vertical farmers believe they are a part of the solution. Connected, precision systems have grown crops at hundreds of times the efficiency of soil-based agriculture. Located in or close to urban centres, they slash farm-to-table time and eliminate logistics. New tech is allowing growers to tamper with light spectra and manipulate plant biology. Critics, however, question the role of vertical farms in our food future. They are towering lunch-boxes for late capitalism, they argue – producing garnishes for the rich when it is the plates of the poor we must fill. Vertical farms already make money, and heavyweights including Amazon and SoftBank are investing in various companies in the hopes of cornering a market expected to be worth almost £10 billion in the next five to ten years. Infarm is leading that race in Europe. It has partnered with European retailers including Aldi, Carrefour and Marks & Spencer. In 2019 it penned a deal with Kroger, America's largest super-market chain. Venture capitalists have

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Left: Infarm crop science director, Pavlos Kalaitzoglou, in his Berlin lab. Right: workers load crops into Infarm's latest generation of grow chamber

handed the firm a total of £228 million. Not bad for a hare-brained experiment that started in a Berlin apartment.

In 2011, a year before he moved to Berlin, Erez Galonska went off-grid. He grew up in a village in his native Israel, but the young nation was growing too, and farms made way for buildings. Soon the village was a town, and its inhabitants ever more disconnected from their natural surroundings.

Galonska's father had studied agriculture, and the son had dreamed of recovering a connection with nature he felt he had lost. The search took him to the mountains of the Canary Islands, where he found a plot of land and got to work. He drank water from springs, drew energy from solar panels and spent long hours farming produce he then sold or bartered at local markets.

When he met his now-wife Osnat Michaeli, "I traded it for love," he says. "Love is stronger than anything." In 2012, the couple, alongside Galonska's brother Guy, who had studied Chinese medicine, moved to Berlin to work on a friend's social media project. But the hunger for self-sufficiency remained. It was "a personal quest," Michaeli says. "How we can be self-sufficient, live off the grid. Food is a big part of that journey."

We meet at a Jewish restaurant in Berlin's historic Gropius Bau art museum. It is mid-morning, and Covid-19 has cleared the tables. But a row of Infarm units whirs away quietly along one wall, producing basil, mint, wasabi rocket (a type of rocket leaf with the punchy flavour of wasabi) and other, more exotic herbs. Such produce was a pipedream for the three Infarm co-founders eight years ago. Growing crops when living on a tropical island was one thing. Doing it in a small apartment, located in the tumbledown Berlin neighbourhood of Neukölln, was quite another. Soon after moving from the Canaries, Erez Galonska typed

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An Infarm employee tends to a batch of seedlings in a special incubator. The plants grow under LED light that emits spectra optimised to each crop



“can you grow without soil” into Google.

Japan had taken to indoor farming in the 1970s, and this bore some helpful information on its techniques. The same was true of illegal cannabis growers, who swapped tips about hydroponics – growing with nutrient-packed water rather than soil – across subreddits.

Several trips to a DIY store later, the trio had what resembled a hydroponic farm. It was a big, chaotic Rube Goldberg machine, and it leaked everywhere. Growing wasn’t simply a case of switching on the lights and waiting. Brightness, nutrients, humidity, temperature – every tweaked metric resulted in an entirely different plant. One experiment yielded a lettuce so fibrous it was like eating plastic. “We failed thousands of times,” Erez Galonska says.

Eventually the team grew some tasty greens. They imagined future restaurant menus boasting of food grown “in-farm”, rather than simply made in-house, and founded Infarm in 2013. But there was a hitch: indoor-grown cannabis sells for around £1,000 per kilo. Lettuce for £1.20. Most of the early vertical farms required



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Top: two of Infarm’s co-founders, Osnat Michaeli and Erez Galonska. **Above:** an Infarm kiosk in the Edeka Supermarket E Center in Berlin

heaps of manual work and operated in the red. “It simply wasn’t a sustainable business model,” Erez Galonska says.

By 2014, they decided to roadshow their idea, and shipped a 1955 Airstream trailer – a brushed-aluminium American icon – to Berlin. The trailer belonged to a former FBI agent, but it was conspicuous in a city of Volkswagens, caravans and Plattenbau buildings. Michaeli and the Galonska brothers transformed it into a mobile vertical farm, then pitched up at an urban garden collective in Berlin’s trendy Kreuzberg district. There they proselytised indoor farming to urban planners, food activists, architects and hackers, handing out salads and running workshops. Fresh, local food – even if it cost a little more – would entice a

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Inside the new vertical farm, trays of produce are tended by automated systems that manage everything from nutrients to how much light they get

growing number of foodies who were interested in where their meals came from. The trailer cost nothing but petrol money to move, and emissions from the growing process itself were almost nil.

When the designer of a swanky hotel across town came by the trailer, he asked if the team could install something similar in his restaurant. “That was really the trigger,” says Guy Galonska. “We rented a workshop and we got to develop a system for them.”

When they installed their first “farm” in a Berlin supermarket, VCs took notice and visited Infarm’s young founders at their Kreuzberg office-cum-kitchen, where they hosted dinner parties featuring Infarm crops. But a return on investment still seemed distant: some investors thought the farms were an art project. Maintaining locations manually was exhausting, and the team almost went bankrupt “two or three times,” Guy Galonska says. “I think all of us got a lot of white hair during that time,” he adds. “It was a very challenging thing to do.”

A €2 million grant from the European Union in 2016 helped. With it came deals to place Infarm units in supermarkets and restaurants across Germany. Managing them all would require something

THE FUTURE OF FOOD

precise, connected and efficient. To become a sustainable business, Infarm would have to behave less like a farm, and more like a tech startup.

For around 2,500 years after King Nebuchadnezzar II of Babylon gifted his wife some hanging gardens, little changed in the world of hydroponic farming. Asian farmers grew rice on giant, terraced paddies, and Aztecs built “chinampa” rigs that floated along the swamps of southern Mexico.

Life magazine published a drawing of stacked homes, each growing its own produce, in 1909, and the term “vertical farming” appeared six years later. The US Air Force fed hydroponically-grown veggies to its troops during World War II, and Nasa explored the tech as a solution for life off-planet. But vertical farming didn’t really capture public imagination until 1999, when Dickson Despommier, a Columbia University professor, devised a 30-storey skyscraper filled with farms. In 2010, Despommier published *The Vertical Farm: Feeding the World in the 21st Century*, which has become the industry’s utopian testament.

“I had no expectations whatsoever that this would turn commercial,” Despommier says. “We just thought it was a good idea, because we didn’t see any other way out of stopping deforestation in favour of farming, and keeping the carbon dioxide content of the atmosphere at a reasonable level. It turned out to be a crazy idea whose time has come.”

The vertical farming concept is simple: growing produce on vertically-stacked levels, rather than side by side in a field. Instead of the Sun, the vertical farm uses artificial light, and where there is ordinarily soil, growers use nutritious water or, in the case of “aeroponic” farms, an evenly-dispersed mist.

Vertical farms take up a vanishing amount of land compared to their conventional cousins. They use almost no water, don’t flush contaminating pesticides into the ecosystem, and can be built where people actually live. But, by and large, they have not functioned as businesses. Only the black-market margins of weed, and Japan’s high-income, high-import food ecosystem, have catered to profit. It costs hundreds of thousands of pounds to erect a mid-sized vertical farm, and energy use is prohibitively high.

Advances in technology are changing this. By bolting automation, machine

learning and cloud-connected software on to vertical farms, firms can trim physical labour, increase capacity and maintain a dizzying range of cultivation variables. Infarm staff at a separate office to the new Berlin farm, located some 23km southeast of Spandau in the Tempelhof district, keep track of “plant recipe” settings at any one of the startup’s 1,220 in-store units, including CO₂ levels, pH and growth cycles, via the company’s Farm Control Cloud Platform, a bit like a giant CCTV room. Machine learning finesses recipes, and keeps each plant as uniform as possible.

Gartenfeld Island’s employees – mechanical and electrical engineers, software developers, crop scientists and biologists – get closer to the produce, but only just. They monitor via an iPad and feed crops into the building’s four massive grow chambers, or farms, each one about the height and width of two London buses, with ventilation systems that whoosh like a subdued turbine hall.

From there on in, robots do the hard work. Inside the farms, a robotic “plant retrieval system” – basically a

tricked-out teddy picker – scoots up and down a perpendicular beam, plucking trays of plants in various stages of growth and shuffling them closer, or further, from LED lights at the summit. The firm claims this reduces service time by 88 per cent. A sliver of window is the only way to see the device in-person: everything is hermetically sealed to keep out pests. “With automation, you invest once and then that price goes down over time,” says Orie Sofer, Infarm’s hardware lab lead. “With human labour, unfortunately, over time the price goes up.”

The number of crop plants varies depending on the produce, but there are usually just under 300 in a “farm” at any one time. Each farm yields the equivalent of 10,000 square metres of land and uses just five litres of water per kilo of food (traditional vegetable farming uses around 322 litres per kg).

Infarm is not alone in this revolution. AeroFarms, a Newark, New Jersey-based startup, feeds an aeroponic mist to roots that are separated from their leaves by a cloth. Its most recent funding round was led by Ingka Group, the parent of



THE FUTURE OF FOOD

Swedish furniture giant IKEA. New York's Bowery Farming, like Infarm, focuses on automation and a proprietary dashboard called BoweryOS that, among other things, takes photos of crops in real time for analysis. Its £123 million in backing comes from investors including Singapore's sovereign fund Temasek. Bowery CEO and founder Irving Fain believes his addressable market "is about a hundred billion dollars a year, just in the US, of crops that we think are good candidates for us to grow."

Leading the vertical farming VC race is Plenty, a San Francisco-headquartered brand that has raised almost half a billion pounds in capital since it was founded in 2013, including a 2020 Series D round led by Masayoshi Son's \$100 billion SoftBank Vision Fund. Plenty feeds its greens with water that trickles down six-metre-tall poles; infrared sensors pour data into an algorithm that nudges the plant's growth recipe accordingly.

Plenty co-founder and chief science officer Nate Storey, who works at the company's test farm in Wyoming, likens these deep-tech solutions to the tools that powered agriculture's most recent revolution: "The tractor allowed farmers to be freed from constraints. Half of their land was dedicated to raising draft animals, and the tractor came along and freed them from a life where they were basically managing animals just so they could plough their land."

For them, he says, automation is similar. "It allows us to get rid of the hardest work – the work that is unpleasant, the work [growers] don't like to do – and focus on the work that really matters."

Infarm differs from the competition on two fronts. The first is its focus on modular design: each component is compatible and scalable, like a giant, noisy LEGO set. Modularity makes it possible to install Infarm units anywhere in the world in a matter of weeks, no matter the size. That enables the company's second USP: its business model. Infarm has no stores, selling

produce instead via its remote units.

Clients tell Infarm which produce they want, and "create a schedule," says Michaeli. "You buy the plants. Everything in the farm is controlled from Tempelhof. Everything that's grown belongs to the client." A chef may demand pesto that's made from particular three-day-aged Greek and Italian basil, for example. Infarm can do that (Tim Raue, Berlin's most famous chef, is a customer). "Everyone stops and asks about the farm," one Berlin store manager says. "It's great to have innovation here."

Infarm has "two big advantages," says Nicola Kerslake, founder of Contain Inc, a Nevada-based agtech financier. "One is that they've figured out how to do product onsite, which is really not very easy. And the other is that they have these great relationships with big purchasers like Marks & Spencer."

"When you look at where the arms race is in this industry," she continues, "it's really been in two areas: How do I get hold of as much capital as possible, and how do I sign up the right partners? Having Marks & Spencer in your back pocket is really useful."

It has helped encourage investors to open their chequebooks. Hiro Tamura, partner at London VC firm Atomico, first met Infarm's founding trio in 2018. A year later he led its £75 million Series B round. "They could roll these things out," he says. "They worked, and they didn't need some industrial sized warehouse to do it. I didn't lean in, I fell into the rabbit hole. And it was incredible. I was like, wow, these guys are thinking about time and speed to market modularity."

Infarm ploughs a chunk of its revenue back into research. In a mezzanine-level lab sitting above the farms at Gartenfeld Island, a dozen white-coated analysts conduct tests on herbs to a soundtrack of Ariana Grande, measuring crop sugar levels, acidity, vitamins, toxicity, antioxidants and more. Via a process of phenotyping – the study of organisms' characteristics relative to their environment – they hope to create more flavourful plants, or new tastes altogether.

"It's not just about the hardware," Kerslake explains. "It's about how the hardware interacts with the rest of your farm system. And we're starting to see a lot more sophistication on that front, because the AI programs these companies started three or four years ago are now starting to bear fruit."

Infarm's results are high-quality: juicy lettuce, wasabi rocket that kicks,

and basil that's far more fragrant than the budget variety. "The end goal with almost everything that we're doing is developing some sort of playbook, some sort of modular and standardised system, that we can then copy-paste to wherever we go," says Pavlos Kalaitzoglou, Infarm's director of plant science. Across from the lab, tomatoes and shiitake mushrooms grow in wine cellar-size chambers. They are living proof of how the firm is looking to diversify from herbs and leafy greens, whose low energy and water requirements make them the staple crop of every vertical farming startup today.

We are in danger of farming the planet to death. Agriculture already occupies 40 per cent of all liveable land on Earth, and food production causes a quarter of all greenhouse gases. An area the size of Scotland disappears from tropical rainforests, responsible for up to a quarter of land photosynthesis, each year. Clearing more trees to feed our spiralling population will not help.

"We need to go back to the drawing board and rethink which avenues we can environmentally afford to pursue," says Nicola Cannon, a professor at the Royal Agricultural University in Cirencester. Nitrogen fertiliser is particularly harmful to the environment, Cannon adds, "and has led us to adopting systems which have grossly exceeded the planetary boundaries."

Current food systems are wildly inefficient: waste accounts for 25 per cent of all calories. And yet, almost a billion people suffer from hunger worldwide. These are not issues vertical farming will solve, critics argue. Going local does little beyond satisfying consumers.

Energy is another tricky issue. Ninety per cent of Infarm's electricity today is renewable, and it wants to reach zero emissions in the next few years. But this doesn't factor in the environmental cost of building a steel-and-cement facility.

"Vertical farms are a round-off error to the round-off error in terms of contributing to the big levers out there," Jonathan Foley, an environmental scientist based in Minneapolis, says. "Like most technologies that are getting a lot of venture capital and which come from Silicon Valley kind of thinking, it's being massively overhyped at the cost of real solutions. There's an opportunity cost to put all this technology, money and renewable energy – that

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Rows of LED-illuminated produce inside one of Infarm's four massive new grow chambers, each one the height and width of a London bus



could be used for other things that we need energy for – into growing arugula for rich people at \$10 an ounce.”

More than half the world’s food energy comes from its three “mega-crops”: wheat, corn and rice. They require wind, seasons and micronutrients that vertical farms are unable to replicate today. These are the crops that can prevent famine in Somalia, Bangladesh or Bolivia – not lettuce. “Vertical farms are growing the edge of the plate, not the centre of the plate,” Foley says.

But Despommier says it’s too soon to criticise the young industry for not addressing issues such as crop diversity. “What you’re really seeing is a rush towards profitability to get their feet wet, and to get their ledgers in the black and to pay off their investors, before they start diversifying,” he says.

“In a world where you think that land is unlimited and that resources are unlimited, indoor farming would be nonsensical,” Plenty co-founder Storey says. “As crazy as it seems to replace the Sun with electricity, it makes sense today. And it really makes

more and more sense as time goes on.”

Much of the hope vested in vertical farms rests on the light-emitting diode. This tiny bead of light is the industry’s packhorse: it is a farm’s biggest financial layout, and the nucleus of its most exciting advances. Modern LEDs are nothing like the ones that powered your childhood TV. They’ve progressed at such a rate, in fact, that they’ve developed their own law to adhere to: “Haitz’s Law”. Each decade, their cost drops by a factor of ten, while the light they generate leaps by a factor of 20.

That curve will eventually plateau, experts say. But not before LEDs improve enough to allow vertical farms to profit from food closer to the middle of the plate. Infarm’s current smart LED set-up is over 50 per cent more efficient than the one that lit its first farms. Haitz’s Law has helped some companies experiment in growing potatoes, which require far more energy and water than leafy greens. Turning profit from a crop that delivers the highest calories per acre would be momentous for the industry.

The cutting edge of LED technology today is smart sensors that can regulate the brightness and spectrum of light to replicate growing outdoors – or enhance it. Much of the planet’s first flora grew only in the ocean, which looks blue because it absorbs blue light least. Photosynthesis, therefore, occurs best between the blue and red light spectra. By tailoring LEDs to emit only these colours, or by dimming at intervals meant to mirror a plant’s natural cycle, vertical farmers can further reduce their energy burden – like stripping a road car to its bare bones so it can drive faster.

Recent discoveries have been more surprising. Strawberries, for example, react particularly well to green light. Some spectra can increase the vitamin C in concentrated fruits like kiwis, while others extend shelf-lives by almost a week. In the future, says Fei Jia, of LED firm Heliospectra, growers “can get feedback from the lighting and the

plants themselves on how the lighting should be applied... to further improve the consistency of the crop quality.”

“If you judge it from what you have today, you understand what [critics] are saying,” Guy Galonska says. “How can you grow rice and wheat and save the world? And they are right. But they can’t see ten years ahead: they can’t see all the different trends that are going to support that revolution.”

Other technological advances are helping agriculture in different ways. Drones and sensors help map and streamline growing. Drip irrigation dramatically reduces the burden on dwindling water supplies. Circular production – where waste products from one process contribute to fuelling another – is becoming more commonplace, especially in livestock farming. Cell-grown or insect-based meat (or vegetarianism) will reduce our reliance on livestock, which consume 45 per cent of the planet’s crops. Infarm, and the broader vertical farm cohort, may not be saving the world today. But it wants to build taller farms, place them in public buildings like schools, and teach people the value of fresh, healthy vegetables. If 70 per cent of us are to live in cities, then cities “can become these communities of growing,” says Erez Galonska.

Ultimately, Infarm wants to build a network of tens of thousands of automated farms, each one pumping streams of data back into a giant AI system in Berlin. This “brain”, as Galonska calls it, will pour that information into algorithms to generate better food at lower costs, each new yield shaving fractions from the water, energy and nutrients required.

Then, Infarm could become something closer to the dream Galonska left behind in the Canaries: truly self-sufficient.

It’s a long way from the leaky, DIY gadget he and his co-founders built in their front room. “The way the world is going now, it’s very clear to everyone it’s running into the wrong direction,” Galonska says. “We definitely believe in the power of collaboration: bringing those outside-the-box thoughts to create a new system that will generate more food, better food, much more sustainably, and help to heal the planet – because that’s the main issue on the table.” ■

Sean Williams is a British reporter and photographer based in Berlin, Germany. His subjects range from human rights and conflict to sport, culture and tech



▲ **Top: a rendering showing how Infarm’s vertical farms can slot into city life.**

Above: Infarm kiosks inside the Beba restaurant in the Gropius Bau museum

A collage of five images. Top left: A yellow rectangular box with a black border containing a blue fish labeled 'YELLOWTAIL AMBERJACK'. Three black lines with arrows point from a round-bottom flask below towards the fish. Top middle: A circular petri dish containing several small, star-shaped cells with circular nuclei. Top right: A cursive signature in black ink, starting with a small American flag. Bottom left: A round-bottom flask filled with blue liquid, with three black lines extending upwards from the liquid towards the fish in the top-left image. Bottom right: A can of 'STEM CELLS' with a red label and a silver top. The label text includes 'STEM CELLS', 'NET WEIGHT', 'IN BRINE', and '7 oz / 198g'.

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BlueNalu will produce high value fillets, rather than the cheaper fish you might find in fishcakes, and will debut its product in restaurants (greater volumes will be needed before it enters retail). It plans to launch one species after another, and test them out as appetizers, lunches and dinners. "The restaurants are very excited because we're offering a product that's available year-round, with a consistent supply and a 100 per cent yield," Cooperhouse says. "So there's just a lot of love."

On the menu for animal feed: protein made from mealworm

Among rolling vineyards in the south of France lies a farm like no other. Forget cattle and crops, this flagship project from French company Ÿnsect is home to billions of *Tenebrio molitor* – mealworm beetles and their larvae. Nurtured from eggs, the beetles are harvested for their protein and processed into a nutritional powder or oil ready for animal or plant feed.

Many insect species have featured as a food staple for centuries, and more recently as quirky meat-free alternatives on eco-restaurant menus. But Ÿnsect's founders hope that using insects to feed animals and plants will help to solve a huge sustainability crisis. By 2050, the World Resources Institute forecasts a 70 per cent human calorie gap, meaning our ability to produce food will need to expand rapidly to meet the needs of the growing global population.

"We are competing with animals for nutrition: livestock consumes 20 per cent of global proteins; meanwhile we have dwindling fish stock, water, land and soil resources," Antoine Hubert, Ÿnsect's co-founder and CEO, says. "It seems obvious and natural, therefore, that we should be focusing

our attention on alternative proteins for animal feed and plant nutrition."

Founded in 2011, Ÿnsect has grown to become a world leader in molityculture. Its flagship site near Dole in Burgundy is the world's first vertical insect farm: at 17 metres high, it has the capacity to produce 1,000 tonnes of insect produce per year while using 98 per cent less land and 50 per cent fewer resources. The company has two flagship products: ŸnMeal, a powder derived from farmed mealworm larvae which can be turned into pellets, and Ÿnoil, an oil rich in polyunsaturated fatty acids. Both are specially adapted to suit the diets of farmed fish and shellfish.

In June 2020, Ÿnsect became the first company in the world to obtain market approval for its insect-based plant fertiliser, which Hubert believes will be a game-changer in terms of both human health and environmental sustainability. "On vineyards, compared to traditional chemical fertiliser, plants were found to grow 25 per cent faster with insect protein – less input, faster results and no chemicals or fossil fuels," he says.

A second vertical farm is currently under construction in Amiens, one

hour north of Paris. At 35 metres high and a total surface area of 40,000m², it will be the largest insect farm in the world, and will use robots with machine-learning software connected to embedded sensors to ensure the *T. molitor* are kept at optimum conditions. The new site is expected to produce up to 200,000 tonnes of protein per year.

It was during a trip to the Scion research centre in New Zealand in 2007 that Hubert first became fascinated by insects as an organic resource. "I was amazed by earthworms," he says. "These soil engineers were providing a solution for organic waste treatment. It seemed to me pretty obvious that we could benefit from their natural behaviour in other ways."

Then an active volunteer and spokesperson for several environmental groups, Hubert went into schools to talk about the need for alternative and sustainable food sources. "But we felt increasingly that there was a gap between what we were teaching and the reality – at this time there were no insect products on the market that were competitive and safe."

In sketching out a business plan to make insect-based products for aquaculture, Hubert's team met with a lot of resistance – "It was like a fun thing that nobody wanted to take seriously." But the world is catching up; the International Platform of Insects for Food and Feed, a monthly committee which Hubert chairs, began with four members in 2014; today it boasts 75 members from across Europe.

In December 2020, the European Commission confirmed that a vote will go ahead to member states to propose opening up the pig and poultry markets to insect protein-based feed from 2021. "Insect proteins cannot solve all of our environmental problems," says Hubert. "We are just part of the story. But in finding more resources and increasing nutrient diversity, we will solve the crisis and make for a fairer world."

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The Ÿnsect team was initially inspired to develop an alternative food source for aquaculture in response to the protein gap created by overfishing

> Insect nurtures *Tenebrio molitor* larvae so their protein can be harvested for use as pellet- and oil-based feed suitable for farmed fish and shellfish

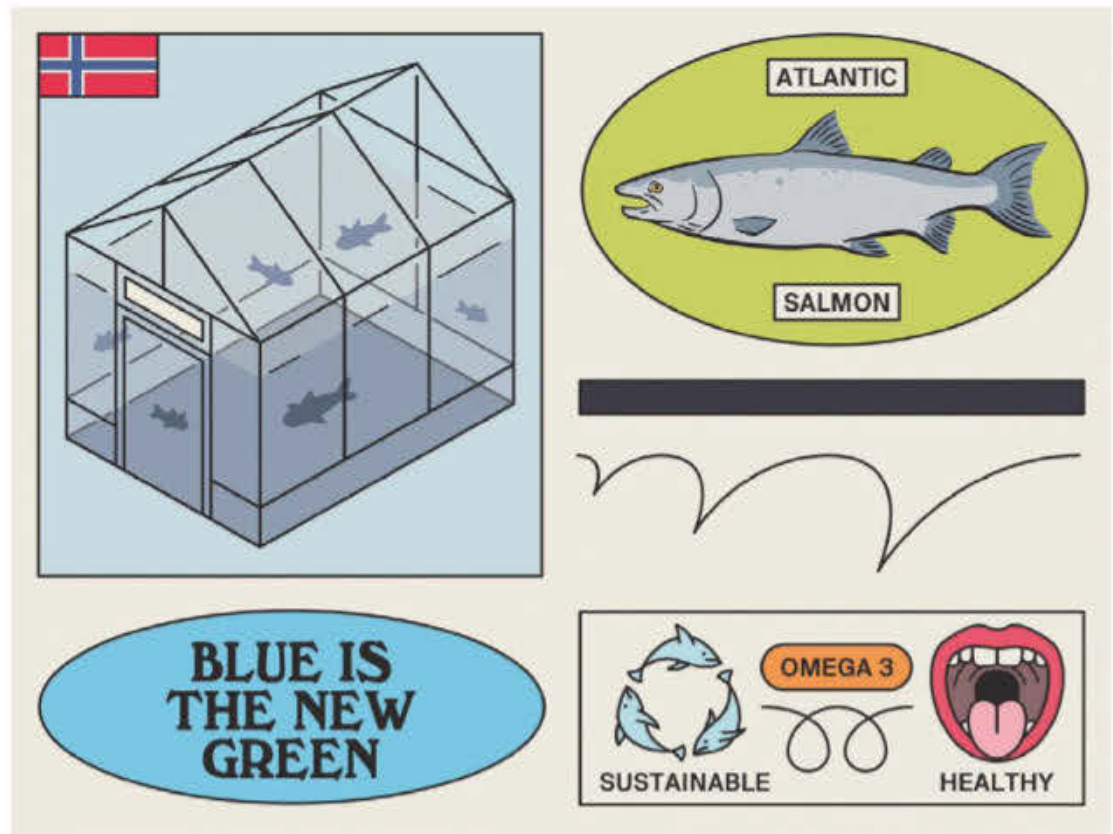


IT'S A WRAP FOR
NON-COMPOSTABLE
PACKAGING

Over 40 per cent of products in the UK are packaged in flexible plastic, but only four per cent of these are recycled, and the rate is even lower globally. Eight out of 11 million tonnes of plastic polluting the ocean comes from flexible packaging. "There is no doubt that plastic packaging is a broken system," says Daphna Nissenbaum, founder and CEO of Israeli startup TIPA, which has developed a range of fully compostable packaging.

TIPA's laminates and films break down under compost conditions – high humidity and temperature, plus microorganisms – within 180 days. While they're made entirely of compostable materials using both bio- and fossil-based derivatives, they have the same functional and optical properties as regular plastic, and they do not adversely affect product shelf-life. The technology "imitates nature's packaging," says Nissenbaum. "Like an orange peel, it protects what it packages before degrading safely."

The packaging is also versatile: supermarkets Ocado and Waitrose are customers, as are Google and fashion retailers Stella McCartney, Gabriela Hearst and Mara Hoffman.



Florida: the new global capital for sustainable fish

Johan Andreassen has farmed salmon for decades, but admits his latest farm, located 24km inland, near Miami, Florida, "doesn't seem logical".

Farmed salmon is normally raised in net pens in Norwegian fjords – this is what Andreassen did with his last company, Villa Organic. But he realised that shipping salmon via air freight to the US, the company's largest market, meant it wasn't truly sustainable.

After selling his stake in Villa Organic, Andreassen co-founded Atlantic Sapphire in 2010 to develop "bluehouses" – like a greenhouse, but for salmon. Fish are kept in different tanks depending on the stage of their life – salmon switch between fresh and sea water as they age – with clean, oxygen-injected water circulating to give the effect of currents.

It hasn't all gone swimmingly: the Florida facility was forced to harvest 200,000 fish early after construction activity sparked damaging "salmon stress", while high nitrogen levels at

the Copenhagen location killed 227,000 fish. But when the system works, the salmon grow to harvestable size six to nine months faster than in the wild.

They're also leaner, because the water current is stronger than in nature. "It becomes very muscular," says Andreassen. "And it has a milder taste, less of what we call the fishy flavour." This appeals to American palates.

While an unnatural location for cold-water fish, Florida's aquifers provide Atlantic Sapphire with stable, clean and biosecure sources of fresh and seawater – dig down deep enough, about 450m, and both are available.

It also needs somewhere to put its wastewater, which isn't toxic but is loaded with nutrients like nitrogen, so can't simply be pumped out to sea. Drill down 900m, and there are cavernous formations of limestone rock. Inject the wastewater, and it's naturally purified. "We couldn't have done this at scale without an environmental impact any other place," says Andreassen.



ROBOT FARMERS MAKE SHORT WORK OF WEEDING

In 2011, French engineers Aymeric Barthes and Gaëtan Séverac began collaborating with farmers to design robots capable of weeding. Not only do Naïo Technologies' machines minimise dependence on chemicals, they also address a shortage of farming labour. "Even in the poorest countries, it's becoming difficult to find people to work in the fields, because it's just too painful," Séverac says.

Around 200 of Naïo Technologies' robots are deployed across Europe, North America and Japan. There are currently three models: Ted, designed for vineyards; Oz, for small farms; and Dino, for large-scale plots. The machines are equipped with mechanical weeding arms, machine learning and GPS navigation. Once the farmer has created a map of each bed, the machine will do the rest – at least, until it needs a recharge.

In January 2020, Naïo raised €14 million to aid its expansion. Besides sales of its robots, it hopes to grow its weeding services and rentals. "In the next ten years, there will be robots in every field of Europe and North America," says Séverac.

Upgrading plants' taste for salt

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By re-engineering plants to tolerate saline conditions more effectively, Agrisea is making the planet's abundant resource of seawater suitable for growing food crops

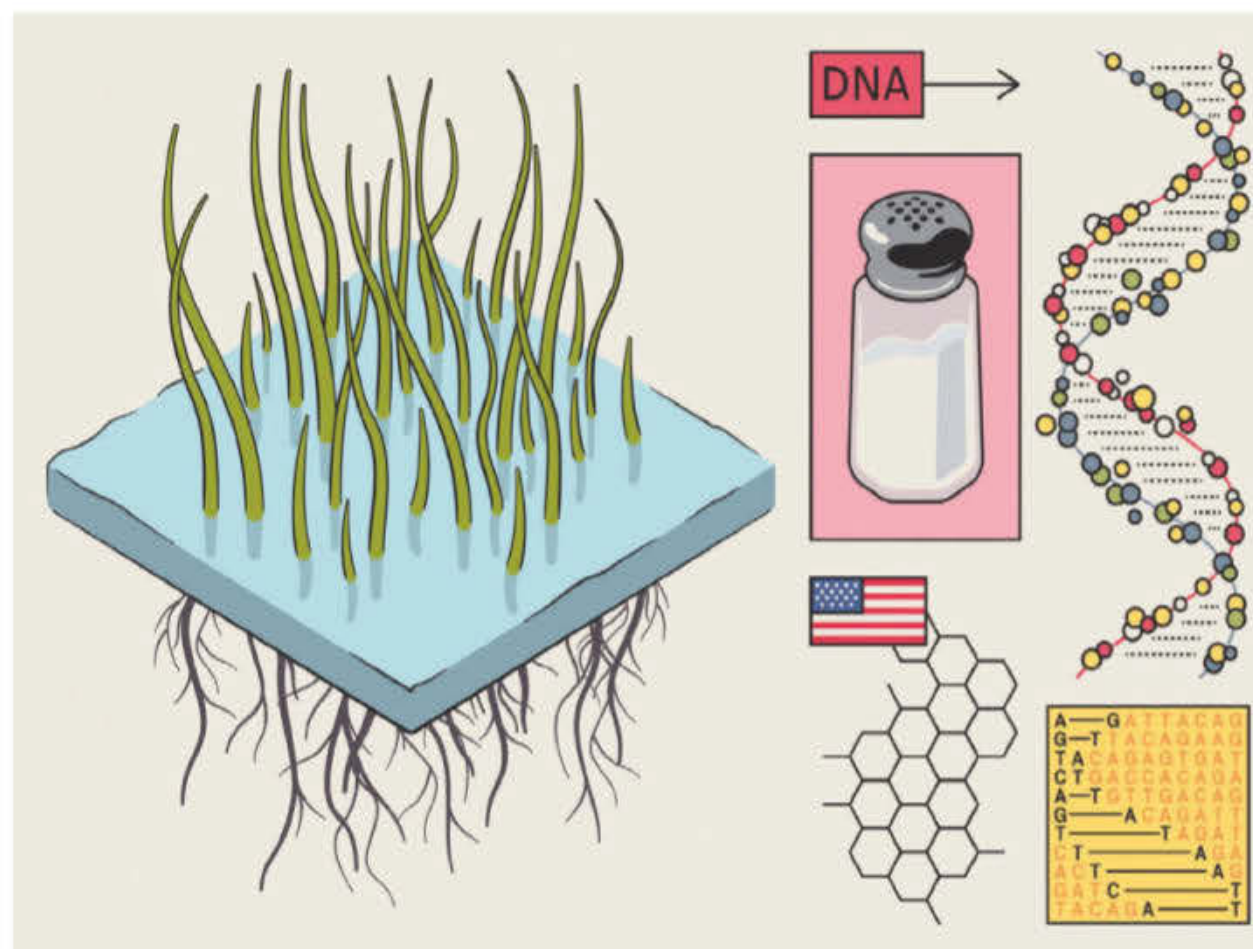
On a trip to Norway in summer 2018, Luke Young looked out across the ocean and saw a vast oil tanker as just a speck on the horizon. It gave him an idea. "It was this epiphany of how much water is available in our oceans, and how we don't utilise that," he says. He couldn't understand why large parts of the world have so little access to the water needed to grow plant crops.

But seawater is salty, and plants can be temperamental. Young spent six months designing vast floating beds for plants, testing his hypotheses with fellow Durham University graduate Rory Hornby. "Every plant has the ability to deal with salt stress," Hornby says. But plants that have evolved to grow on land have minimised this. Their company, Agrisea, isolates the most important genes for acquiring salt tolerance and upregulates (increases

the quantity of) them. This allows the crops to grow as well at sea as on land.

Owing to differences in regulations around plant gene-editing, Agrisea moved to the US: first to San Francisco to join the IndieBio accelerator, then to the Velocity startup incubator in Kitchener, Ontario, where it is still based. In late 2020, the company raised \$500,000 from Mistletoe Singapore, and a further \$85,000 from angel investors to start its first field trials.

Two plots in the Bahamas will grow rice on the water at slightly smaller than commercial scale. If it works, the crop will be licensed to companies in Vietnam's Mekong Delta in mid-2021. "The rice variety we're creating is able to deal with [current levels] of salt intrusion, but also [that of] the next 30 years," says Hornby. "It allows this industry to be preserved in that location."



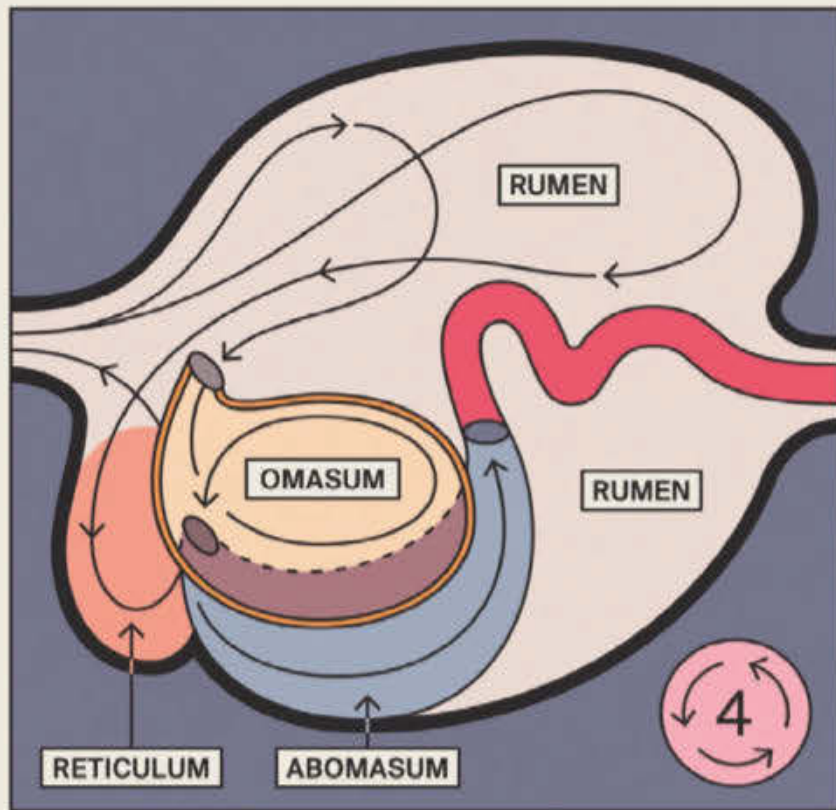
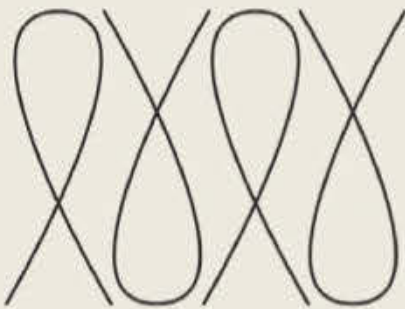
> To dose the world's livestock feed with *Asparagopsis taxiformis*, the seaweed needs to be engineered to grow as an easily harvested crop



GOAT →



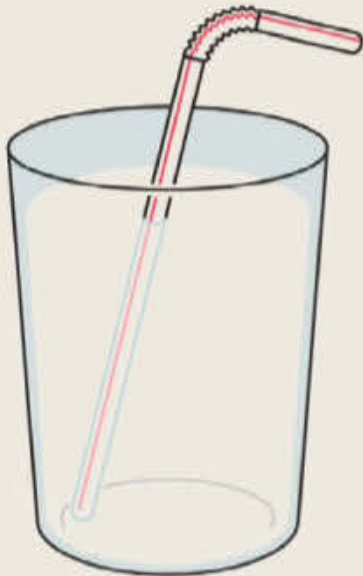
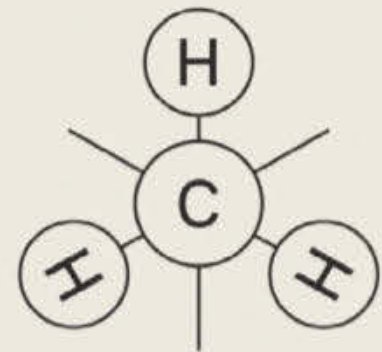
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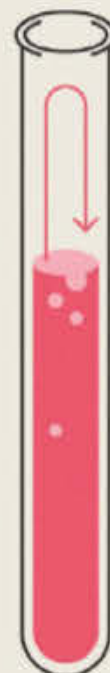
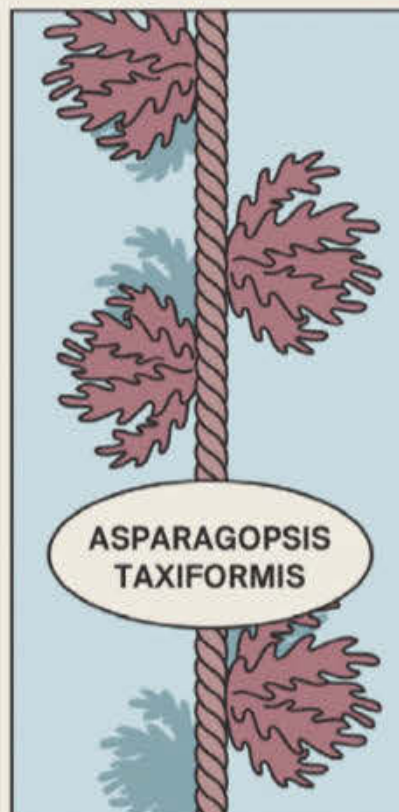
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→ OF MAN-MADE GLOBAL WARMING



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Greener Grazing: how seaweed kills cow burps

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Adding a dash of *Asparagopsis taxiformis* to cattle feed can cut methane emissions by up to 85 per cent – but we need to find a way to grow 200 million tonnes of it a year...

Cow burps are killing the planet. Livestock contributes 14.5 per cent of human-caused greenhouse gas emissions, according to the UN's Food and Agriculture Organisation, and cows make up two-thirds of that figure. Four years ago, Josh Goldman read research from Australia's national research agency CSIRO and James Cook University in Queensland that suggested a solution: seaweed.

Sprinkle a tiny bit of *Asparagopsis taxiformis* into a cow's dinner, making up about 0.2 per cent of their total meal, and they burp 85 per cent less methane – and, early trials show, require less food overall, as all that belching wastes energy. But for this red seaweed to solve cow burps, it must be easy to grow: we'll need 200 million tonnes of it.

To help tackle the growth challenge, Goldman was directed to seaweed researcher Leonardo Mata, who has been studying the plant for decades and at the time was the only one to cultivate it. Their collaboration has become Greener Grazing, part of Goldman's wider sustainable farming firm Australis Aquaculture.

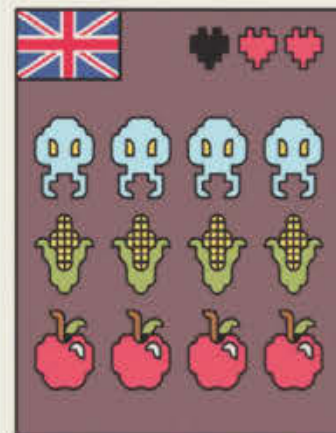
There are two main types of seaweed, Goldman says. "One is seaweed that to cultivate you literally take a big

plant, cut it up, and then tie or glue the cuttings to a rope and they regrow. But other seaweeds have much more complex life stories, and this falls into that second category."

To successfully dose the world's cattle, Greener Grazing is trying to make *Asparagopsis taxiformis* morph into the simpler type of seaweed. This involves developing a seed bank to study the seaweed's genetics and unpick what is needed to make it grow on land long enough to induce a process called sporogenesis, which gets the seaweed to release spores. "We collect those, clean them up and stick them to ropes that we can transfer to the ocean," Goldman says.

Ocean trials are currently running in Vietnam, and the first commercial harvest is planned for 2021, though work remains to refine the process so it can scale cost-effectively. The aim is to supply spore-seeded ropes to farmers, but also to process the harvested seaweed to extract the key compound, known as bromoform.

As the seaweed also absorbs CO₂, Goldman hopes there'll be an added environmental benefit: "The oceans are getting more acidic, and seaweed farming is a way to combat that."



FARMING WITH DATA TO ENSURE FOOD FOR ALL

Farmers must monitor weather forecasts and soil moisture data, track inventory, and protect their crops against pests and disease. AGRIVI's cloud-based software allows them to manage all of this through one central application, and provides in-depth analytics.

AGRIVI was founded in 2013 by Matija Zulj, a Croatian communications technology expert who recognised that farmers need tools to run their farms more efficiently and sustainably. AGRIVI's line comprises basic Farm Management software for individual growers, delivered as a self-service platform on subscription, as well as Enterprise Farm Management for larger companies, and a Farmer Network Management tool for organisations that oversee networks of farmers. Kimberly-Clark, Driscoll's and Nestlé all use the software, while governments also use it to raise national agriculture production and acquire data for policy-making.

The company recently secured €4 million in funding to expand into key European markets and the US. "The market wasn't ready until now," Zulj says. "We needed the generation shift for innovation and data-driven solutions."

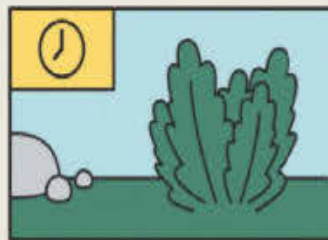
AN ELECTRIFYING NEW APPROACH TO KILLING WEEDS

RootWave's technology zaps weeds from the roots upwards, boiling them inside out. Against a backdrop of herbicide-resistant weeds and growing awareness of agrochemicals' dangers, the Warwickshire startup hopes its systems could have an impact on safe and sustainable weed control. "The world desperately needs an alternative [to

agrochemicals] that is energy efficient, highly efficacious and scalable," explains RootWave CEO Andrew Diprose.

RootWave doesn't generate the heat externally; instead, its method applies electricity directly via a probe, causing a current to pass through the plant, destroying its cells. Not only is this cost efficient because the energy is targeted, it is highly effective as it kills the roots, meaning regrowth is low and, importantly, it doesn't disturb the

soil. Its system has been made possible due to advancements in modern electronics; in particular, inverter technology that controls the frequency



and amplitude of the generated electricity.

RootWave is currently a hand-held device, but will soon be used on a larger scale. It is partnering with experts in identifying and targeting weeds, including German agricultural engineering company LEMKEN, SFM Technology and farm robotics startup Small Robot Company; after experimenting in controlled environments, they will move to trickier plots, where cameras and robotics will distinguish between farmers' "wanted" and "unwanted" plants.

WORDS: WILLIAM RALSTON; CHRIS STOKEL-WALKER. ILLUSTRATION: JACQUES KLEYNHANS

Researching life on other planets led to finding protein-packed microbes

It was a Nasa mission that gave rise to the idea behind Nature's Fynd, the US company behind a fungi-based protein that could revolutionise the way we source protein. The company's co-founder, Mark Kozubal, was gathering lifeforms that survive in extreme environments in Yellowstone National Park's acidic springs in 2009 as part of a project to explore life on other planets. He came across a microbe, *Fusarium* strain *flavolapis*, that proved particularly hardy – and which also produced vast amounts of

> In 2020, Nature's Fynd took over a 3,250 square metre factory in the heart of Chicago's meatpacking area, where it will grow *Fusarium* at scale

protein. "Once we discovered we had this great-quality protein, that put us on a quest to find a way to make it into delicious food," says Thomas Jonas, one of Kozubal's co-founders.

For millennia, we've picked from the low-hanging fruit of nature for food – often literally. But environmental stresses on our planet and a ballooning population mean we need to find alternatives, especially when it comes to protein. The microbe Kozubal discovered, rebranded "Fy", is one potential solution. "If you think about it, there's no reason why it'd be fundamentally different to domesticate a cow than it is to domesticate microbes," says Jonas. "Catching the first cow years ago can't have been that easy."

Fy is ideal because it has a powerful nutritional profile, jam-packed with protein. More than 50 per cent of Fy is protein, with additional fibres, oils and vitamins. It's also adaptable, able to be used in everything from

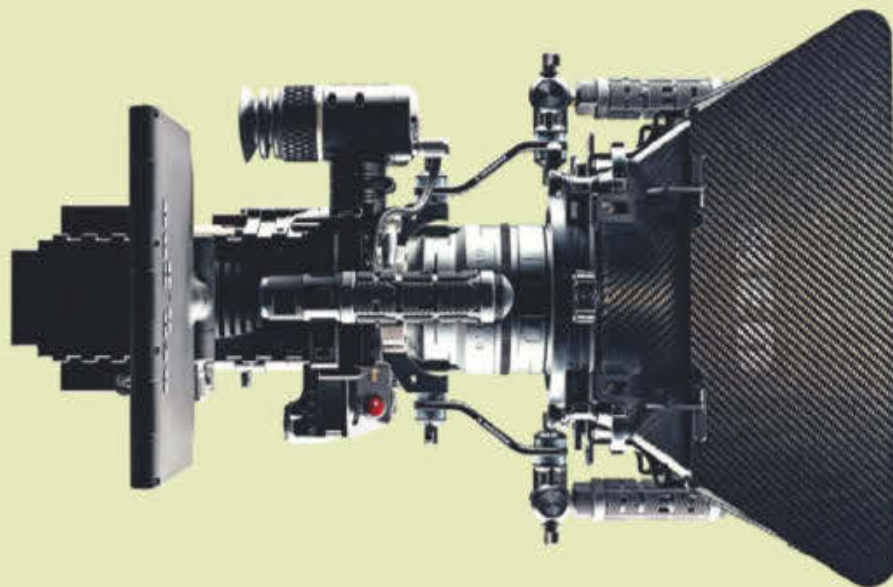
animal-free cream cheese to "pork" dumplings and chocolate mousse. Fy is grown using a liquid-air interface fermentation process in trays on racks inside a growth chamber. The whole process takes a few days. Requiring minimal further processing, the tiny microbe can be transformed into food products using current food science and technology methods.

In February 2019, Nature's Fynd received \$33 million in funding, and a further \$80 million a year later. Investors include Breakthrough Energy Ventures, backed by Bill Gates, Mark Zuckerberg and Jeff Bezos, as well as Al Gore's Generation Investment Management. "That shows our attempt to develop a new food system that can give us a fighting chance against climate change," says Jonas.

The money is being used to bring the company's Fynd-branded products, containing the Fy protein, to supermarket shelves in the US later in 2021. ■

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Hikikomori

– people who retreat from the world, often for years – are the hidden crisis of our time. And Covid-19 may have made it even worse, driving many deeper into their isolation



One day in 2009, a nervous young man rushed out of his home in Incheon, South Korea, head held down.

Having not showered in weeks, his skin was oily, his hair unkempt. The loungewear he had on, one of only two sets he owned, was badly stained. He knew he smelled. But he'd run out of necessities, so he'd have to go to the shop down the street. It'd just be five minutes. All he had to do was stock up on instant ramen, Coke and cigarettes, and then he'd be back.

After picking up his supplies, the man walked back home. But as he was approaching the front entrance, a panic spread over him: he didn't know the passcode to open the door. It had been so long since he'd gone outside, he'd forgotten how to get back in.

At this time, Kim Jae-ju was 29 years old and in the most extreme phase of his social seclusion. He'd already spent, off and on – but mostly on – two years in his bedroom, and he would go on to spend another eight in the same manner. In this three-metre-by-three-metre box, with little more furniture than a bed, desk and chair, Kim kept confined for close to 24 hours a day, seven days a week, 52 weeks a year – eating and smoking and staring at his computer screen.

He left only when he absolutely had to – to run to the bathroom, meet the food delivery driver, refill supplies and, very occasionally, go to work to earn a bit of money. Though Kim lived with his family, his room down the hall from his parents' and younger sister's, he saw them just once a month. He'd synchronize his comings and goings to avoid everyone, rushing out and back in when they were at work or asleep.

Time passed in this way for a decade. The door opened and closed. Outside, the world changed, but inside, Kim did not. No matter how many times he left his room, he would always – and it seemed to him, inevitably – return. "When I look back on that period, it makes me feel incredibly sad," he says, now 41. "I lost ten years of my life."

Right: Yoo Seung-gyu went from hikikomori to working as a programme manager at the K2 centre, where he now helps others like himself



In South Korea, people like Kim are known as hikikomori.

It's a Japanese word without a precise translation, but it broadly means "to pull back" and "shut oneself in". South Koreans first borrowed the term when the phenomenon was newly emerging in the country in the early 2000s, and it is still more popularly used than the Korean term *eundonhyeong oiteollie*.

Hikikomori are mostly men in their teens, 20s and 30s. They reside alone or, more often, hole up in a bedroom at their parents' home. Because they hide from public view, it's hard to know exactly how many there are in South Korea, but the government estimates around 320,000. Some psychologists and former hikikomori believe the total is closer to 500,000. Others say over a million.

The term hikikomori was coined in 1998 by Japanese psychologist Saitō Tamaki, and is used to refer to both the person and their condition. In his book *Social Withdrawal: Adolescence Without End*, Saitō defines hikikomori as "those who withdraw entirely from society and stay within their own homes for more than six months... and for whom other psychiatric disorders do not better explain the primary causes of this condition." In 2003, the Japanese government came out with its own, very similar definition. In extreme cases, the withdrawal can span a decade or longer.

Because there are no standardised criteria for hikikomori, who qualifies is up for debate. The stereotype looks much like Kim – a twenty-something East Asian male who hasn't socialised in so long he's completely forgotten how. But in addition to this "hardcore" type, some researchers have hypothesised a "soft" type, who might occasionally talk to other people. They have also proposed so-called "secondary" hikikomori, whose social avoidance can be attributed to an underlying psychiatric disorder – say, depression – and "primary" hikikomori, who do not have

another condition. Others, like Saitō, argue that only the latter can really be considered hikikomori. "This alludes to directional uncertainty on whether prolonged social withdrawal is caused by, correlated with, or causes psychiatric disorders," researchers write in a 2019 article in *Frontiers in Psychiatry*.

Although Japan was the first to identify, name and study hikikomori, cases have since been reported across Asia, but perhaps most prominently in South Korea, Japan's closest neighbour. Whether the phenomenon occurs outside of Asia is a point of controversy. Many researchers point to documented instances in the US, Europe and other countries. Some, though, contend the syndrome is "culture-bound", meaning it arises out of, and is unique to, the cultural context of Asian countries, with their particular emphasis on notions of shame, conformity, hierarchy, family structure and individual industrialism for national success. In recent years, this idea that hikikomori is "culture-bound" has given way to the broader "culture-influenced".

Lee Ah Dang is a counseling centre in Seoul that specialises in hikikomori. Its clinical psychologists say that, while their patients have varied widely in their individual conditions and rehabilitation needs, most have something in common: they feel they can't cope in South Korea's ultra-competitive society.

Lead psychologist Park Dae-ryeong says that this atmosphere, along with a poor job market, has put overwhelming pressure on people to perform, while disincentivising collaboration, discouraging the pursuit of passions and exacerbating feelings of inadequacy, disappointment and anxiety. Many young South Koreans compare their lives to running on a hamster wheel.

It doesn't help that South Korean society's concept of success is so

rigidly defined. Lee Ah Dang says that because hikikomori live outside the mainstream, they have often been subjected to some form of ostracism or marginalisation. They may have been pushed to conform to convention – and then rejected for failing to do so.

In Kim Ho-seon's case, being more interested in hair and makeup than maths and science meant he didn't get along well in secondary school and ended up dropping out. "It didn't feel right doing things I didn't want to do," the 25-year-old says. After struggling with judgment and stigmatisation, he ended up calling the police to ask for help with his psychological problems.

Similarly, Yoo Seung-gyu, 27, says his goals didn't live up to South Korea's standards. He dreamed of being a content creator, he says, but was belittled until he lost all confidence. Lee Seung-taek, 24, says that not having any lofty plans for the future made him a social outcast. All he wanted was to earn a decent living and lead a simple life. But that wasn't ambitious enough for everyone else – except for his father. When Lee was 16, his dad became ill, and in 2016 he died. "I became evasive. I ran away," he says. "I could only achieve so much without my father, so why try?"

For Kim Jae-ju, his retreat from public life came after the breakdown of a relationship. Before that, he was on the road toward marriage and children and saw himself as a different person: outgoing, talkative, friendly. In retrospect, he now thinks it was all a show. Trying so earnestly to be the confident extrovert was a way of covering up that, in truth, he was not. He began his withdrawal by turning down friends' invitations to dinner or drinks. That escalated to changing his phone number and not telling anyone but his family.

Finally, Kim says, he "crawled into his room" and entered seclusion. He gained 27 kilos and his skin became dotted with acne. His room deteriorated, too. Disposable noodle cups and empty bottles and cans collected in heaps. Ash and dust cloaked the furniture, and the once-white walls turned a dingy brown. Looking back on his confinement, Kim says he's repulsed. "One day became two days, then three days, then a year," he says. "I started thinking, 'Maybe this lifestyle is okay?' And my new friends just became the computer in my room."

If hikikomori are the misfit underdogs of their stories, their computers are their steadfast sidekicks.

While excessive tech usage doesn't cause hikikomori, researchers say, it does help make their confinement possible. What previously required some interaction with society – feeding, clothing and entertaining oneself – now calls for nothing but the internet.

It's for this reason that some researchers suggest the phenomenon is not so much culture-bound as it is society-bound – a reaction, perhaps, to the internet-enabled changes that make for an increasingly global society. "Hikikomori could represent the clinical answer to a social evolution," write Italian psychiatrists in a 2020 paper in the *International Journal of Psychiatry in Clinical Practice*. This echoes the suggestion by Japanese researchers in a 2018 edition of the World Psychiatric Association's official journal: "Within decades, following further advances in internet society, more and more people may come to live a hikikomori-like existence."

Fourteen years ago, when Kim first began retreating, "untact", a

portmanteau of "un" and "contact", was a yet-to-be-named concept in South Korea. Now, it's a full-blown industry, making it easier than ever for hikikomori to live invisibly. "In Korea, it is so convenient to live alone," Yoo says. "We have an amazing delivery and on-demand system. The whole environment, from restaurants to entertainment, facilitates hikikomori, and everything caters to the single lifestyle."

When hikikomori need to eat, they can order takeout with Yogiyo or Baedal Minjok, the country's two major food-delivery apps, paying digitally and selecting contactless service so that the driver skips the face-to-face handoff and instead alerts them with a text that their meal is waiting on their doorstep (although often their mothers cook their meals and leave them outside their rooms). When hikikomori need to buy essentials, they can shop on the e-commerce site Coupang (although again, it's often the case that their mothers shop for them). When they want to entertain themselves, they can watch a movie on Netflix or play a game online. And when they want to engage in some form of social interaction, they can turn to the non-threatening environment of forums, where they can shield themselves with anonymity.

When he was secluded in his room, Kim's companions were the characters in the dramas he streamed and the vloggers he watched on YouTube. They were the porn stars he was intimate with and the avatars in the first-person shooter games he played. Aside from one friend he texted from his former life, the only other people he talked to were fellow gamers. While playing *Sudden Attack*, his favourite game, he would type to them in the chat. It wasn't anything meaningful, little more than a jumble of gaming slang, but it was routine. After five years of casual chatting, there was one gamer in particular, whose real name he never knew, with whom he thought he'd formed something of a connection.

But, in Kim's eyes, his most important connection of all was the search engine. The internet made his room feel deceptively expansive, as each new search result led him in a different direction, down another rabbit hole, to another discovery. "My biggest friend and enemy was Google," he says. "It never gave

me the time to feel bored. I was always entertained. Whenever I searched for something, it was always there."

If technology enables hikikomori to stay in, however, it can also give them the push to get out. It was when Yoo came across a study online mentioning a rehabilitation group called K2 International that he says he finally gained the courage to seek help. Kim Ho-seon says he was bingeing YouTube when he happened to see an ad for the same organisation that inspired him to escape his self-imprisonment. Within a month, both had moved out of their rooms and into K2. After a year, Yoo even became a programme manager there.

The foundational activity at K2 is communal living. It was founded in Yokohama, Japan, in 1988, and has since expanded to Australia, New Zealand and South Korea, where, for the past eight years, it has run a shared house on a quiet street in northern Seoul. Here, 14 hikikomori, including Yoo and Kim Ho-seon, live together in a three-storey brick building, where the staff encourage them to establish healthy habits, complete assigned chores, keep up their hygiene and follow a routine. Funding from an organisation called the Korea Youth Foundation means that K2 is able to offer the housing rent-free to some of its residents.

In addition to supporting communal living, the Korea Youth Foundation co-ordinates between K2, Lee Ah Dang and a nonprofit called Gong Gam In to provide hikikomori with one-on-one counseling, group therapy, activity clubs, employment training, job search assistance, socialisation practice and educational programming like lectures and creative workshops. Gong Gam In also manages a support group for the parents of hikikomori.

There is scant evidence on how best to treat hikikomori. Because the field lacks wide-scale systematic review, there has been very little research that would make it possible to know which of the variously offered treatments, from psychotherapy to medication, are effective. What is known is that because hikikomori vary so widely, individualised treatment is necessary. To that end, further international study is crucial. If psychiatrists can work towards a



Left: the K2 centre in northern Seoul. Here, 14 hikikomori live together and re-learn skills such as socialising and personal hygiene

greater clinical understanding of the phenomenon, it will help promote not only earlier detection, but also improved assessment and services.

Technology may have a bigger role to play, too. Some researchers have been trying to figure out how to hijack hikikomori's computer usage for interventionist purposes, perhaps by using augmented reality to entice people outside, introducing therapeutic gaming to build self-esteem or trying out virtual reality exposure therapy to practice skills such as maintaining eye contact and being in group settings.

But advocates contend that the most important thing is for the government to do more. "There is no national support to help hikikomori," says Yeo In-joong, the first psychiatrist to identify reclusive types in South Korea. In a 2013 Korean study of hikikomori, 20 per cent believed that had they been helped earlier, they wouldn't be in their situation.

It sounds silly, Kim Jae-ju says, but the online encounter that propelled him toward rehabilitation was a reality TV competition for aspiring K-pop stars.

"I saw this young kid putting so much effort into achieving their dream," he recalls. "That made me realise the reality I was in, and question what I was doing."

First, he got to work cleaning his room. Then, he turned his attention to himself. It had been so long since he'd been a part of society, he no longer knew how to behave or what to say. But he did know where he could begin to relearn. From that point on, Kim dedicated nearly all of his time to readying himself for the outside world. He watched TED Talks on self-acceptance and empathy, and YouTube videos about the art of conversation, weight loss and skincare. He studied up on all the new slang he'd missed while in seclusion. He Googled "how to tell a joke". For Kim, it all felt as heady as a

drug. For the first time in a long time, he was thinking about the future – and was looking forward to it.

But when he shared his new plans with his *Sudden Attack* buddy, he was met with disinterest. "Even though I had been playing games with this person for the past five years, he didn't care at all," Kim says – which gave him all the more motivation to get out. After months of preparation he was finally ready. Venturing out of his room, his first voluntary outing to a public event in a decade was to attend a lecture in Seoul about self-esteem.

Kim continued to seek out social activities that would help him reintegrate. He wrote and published a book, *Unexpectedly Hikikomori for 10 Years*. He lent his expertise to government officials, who were growing alarmed by this once-hidden phenomenon now emerging from the shadows, and its potential societal impact. He also

Ahn Yoon-seung
(*right*) and Yoo
Seung-gyu (*below*)
in the K2 centre
in Seoul, where
hikikomori work
to reintegrate back
into society



‘When I look back on that period, it makes me feel incredibly sad. I lost ten years of my life’

Below: Kim Ho-seon in his room at the K2 centre. He says he saw an advert for the facility during a YouTube binge, and it inspired him to change his way of life



Right: Ahn Yoon-seung was awaiting news of a job offer when Covid-19 struck, causing a delay of over a month and potentially triggering a return to his old life



started advising reintegration groups and mentoring other hikikomori.

Ultimately, Kim's hard work led him to the chance to launch his own rehabilitation venture, a space with food and drinks and games, where all the people who reminded him of his former self could come and take a peek at life beyond four walls. Partnering with a social enterprise company that had some government funding, Kim opened a cafe he called Playground. He also started making plans to move into his own place in Seoul. He couldn't wait.

"Korea loves fads," he says. "When there was the figure skating queen Kim Yuna, everyone sent their kids to skating lessons. When there is a golf star, everyone takes golf lessons. I wanted to be that successful example for hikikomori. My dream was to be standing outside the cafe and to see someone who used to come here walk past and tell me they got a job."

In 2020, hikikomori found themselves confronted with a new reason to fear the world outside. In January, reports of the novel coronavirus in China took over news headlines, and, soon after, the infection appeared in South Korea.

It would be easy to assume that amid a public health crisis that makes shared spaces so dangerous, hikikomori, already accustomed to solitude, would fare better than most. But they are not immune to pandemic pain. For those currently secluded, there is a risk their isolation may only get more severe, making it harder to reintegrate later. For those who have begun efforts at rehabilitation, there is the risk of relapse.

The Korea Youth Foundation's work was suspended for much of 2020. As more and more was cancelled, recovering hikikomori found themselves with less and less to do. "There was nothing fun or meaningful anymore," says Yoo, the programme manager at K2. "Some

people were sad because their opportunities were gone. Some were depressed. I felt concerned for them."

Ahn Yoon-seung, a resident at K2, had applied for a role as a cafeteria worker at a secondary school and was anxiously awaiting a job offer. But because of Covid-19, it was delayed by over a month. He started to spiral. "I saw myself back in my old life, not doing anything," he says. "I was worried that all the things I'd planned for might fizzle out, that nothing would work out for me." Kim Ho-seon also wondered if he might be set back. "I don't identify as hikikomori now, but I could return to that lifestyle at any moment," he says.

Since the start of the pandemic, psychologists at Lee Ah Dang say they've observed increased stress, loneliness and despair among hikikomori. In one case, a woman who had improved so much that she was ready to find a job ended up completely

regressing. Because of Covid-19, she couldn't receive face-to-face assistance for two weeks, a gap that proved too long. "The pressure of doing it on her own was too much," says Han Chae-won, a psychologist at Lee Ah Dang. "So she gave up."

Lee Ah Dang switched its individual counselling from in-person to Zoom, but found it simply was not as effective. Some hikikomori even declined to participate. "Because they're hikikomori, you might think that they would prefer Zoom or phone calls, but ironically, they don't," says Park, the lead psychologist. "They're not used to it." A 2014 study of male hikikomori across four countries found significantly more interest in in-person therapy than webcam therapy.

One reason for this may be privacy concerns. For many, talking from home means family members might be able to overhear. But most crucially, online meetings are not able to provide the same intensive therapy as in-person meetings. "When we met through Zoom, patients didn't feel like they were really meeting me, and they didn't have the same connection to me that they used to have," says Lee Seung-min, another psychologist at Lee Ah Dang. "With in-person, you can look into each other's eyes, you can hear each other's breath – it's more humane. With Zoom, it feels like there is more distance, so some people became even more isolated and

depressed." It wasn't long before the clinic abandoned virtual sessions.

Another challenge for counsellors was the anxiety some hikikomori felt over the virus – a public health crisis seeming the worst possible time to rejoin society. Many who had previously been in touch with the Korea Youth Foundation to begin their rehabilitation ended up backtracking, according to co-ordinator Park Jae-young, with about 30 per cent postponing their start dates or no longer answering the centre's phone calls. "For some of these, the pandemic might have given them an excuse not to recover," he says. "Because of this long period of time without any meetings, it worsened their fear of society."

For those considering reintegration, he says, timing is everything: "It takes a lot of courage for them to ask for help." If systems and staff aren't ready the moment they do, there's a good chance they'll quit. To be hoping so desperately for change, and to have Covid-19 push it back, can be catastrophic.

And it's not only current hikikomori that care providers are worried about. "Everyone has this small desire within to seclude from society... In this era of the coronavirus, it kind of ignites that tendency," says Nam Ki-woong, manager of the Korea Youth Foundation. "We are concerned that if the pandemic continues for a long time, there might be even more hikikomori created."

As the pandemic progressed, Kim could see cafes were suffering, but he couldn't help but hope that his might survive the slump. Despite multiple postponements, he forged ahead and opened Playground in May. But the dream was short-lived. Ministry resources were redirected. Funds dwindled. On some days, the cafe only saw one or two visitors. When it was forced to shutter in October, Kim was let go.

Now, with his life on hold, Kim finds himself exactly where he was before – in his room. "It's disappointing to be tied to my room when I had an opportunity to get out. I've been waiting for this moment, to be part of society, for many years," he says. "Physically, I am used to being at home, but psychologically, I am nervous and worried it will trigger me to repeat the isolated life." When he thinks about those ten years, though, he knows he won't.

Not long after seeing the K-pop episode that changed his life, Kim watched another online video that both terrified and galvanised him. This one was about eternal return, the idea that the dead are destined to repeat their former errors again and again in the afterlife. "I was afraid of living a life where I wasn't able to communicate with other people, a life where I was secluded in my room, a life where I couldn't speak out about the things that I want to speak out about, a life filled with low self-esteem," he says. "To think that I had to live that same life over again felt miserable."

Reflecting on the pandemic, Kim makes a comparison. "Someone who's been living in the cold climate for a long period of time, like I have, is able to continue on in the cold weather," he says. "But if that person is from a hot place, they will find it hard to adapt to the suddenly freezing climate. I would say I'm numb to the coronavirus situation because I am so used to being secluded in my room. But I wouldn't say I'm completely indifferent to it, because I've experienced, briefly, the warmth of being part of society." ☐

Ann Babe is a freelance Korean-American journalist based in Seoul writing about the Koreas, inequality and injustice. Translation work by Kang Jae-eun

'I don't identify as hikikomori now, but I could return to it at any moment'

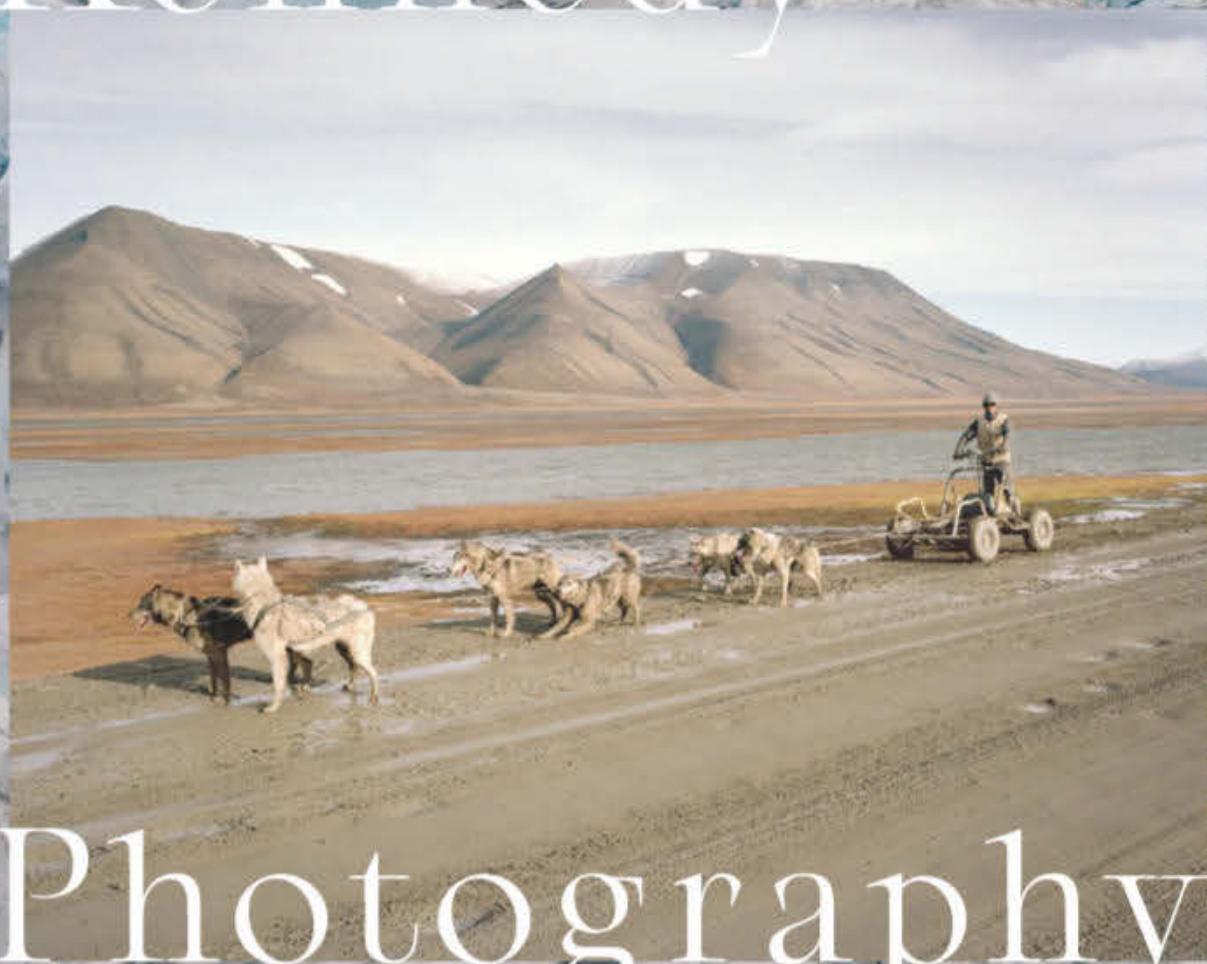
An aerial photograph of a vast, textured glacier landscape. The ice is broken into numerous small, jagged chunks and ridges, creating a complex, undulating surface. The colors range from pale blue to a more vibrant turquoise. In the upper left corner, a small, dark bird is captured in flight against the lighter sky.

At the of the Earth

Two female citizen scientists are on a mission to fight global heating where its effects are most vivid: the Norwegian archipelago of Svalbard

end

By Tristan
Kennedy



Photography
Catherine
Hyland

ilde Fåln Strøm didn't realise it was a polar bear at first. Reaching the crest of the ridge on her snowmobile, she could make out Bamsebu, the remote trapper's cabin where she and her expedition partner, Sunniva Sorby, were spending the long, dark months of the Arctic winter. But as she peered through the blackness of the February afternoon, the familiar shape of the hut appeared to be hidden behind what looked like a large snowdrift.

For the first time, the pair had decided to leave their dog, a two-year-old Alaskan Malamute called Ettra, behind when heading out to explore. They had also left their hand auger – the heavy manual drill they used to take samples of the ice – in its bright red box outside the front door. But as Strøm swung the snowmobile round, catching the cabin in the beam of its powerful spotlights, neither she nor Sorby, riding pillion, remembered that.

"I saw the dark hut, the white polar bear, and something red," Strøm says, speaking on her return from Bamsebu in September 2020. "I was so scared."

Most people, confronted by the realisation that their dog had probably been killed by a polar bear, might think twice about approaching it. Strøm gunned the throttle. To her surprise, the bear initially stood its ground. "Then, just before I had to turn in order not to crash into him, he took off," she says. It was only then that she saw Ettra – sheltering in the doorway, apparently quite unharmed.

Polar bear encounters are nothing new on Svalbard. Stories of protracted battles with the animals began filtering back to Europe as early as the 1600s, when whalers and walrus hunters first arrived on this cluster of heavily glaciated

islands, around 1,000 kilometres from the North Pole. Fur trappers followed, building isolated huts such as Bamsebu, 140 kilometres from the nearest neighbours, to pursue their livelihoods over winter. They braved not just the bears, but temperatures that frequently fell below -30°C , and three months without sunlight – the long darkness of the polar night.

By the time Strøm and Sorby set out in September 2019, hoping to become the first all-female team to overwinter in the manner of these early pioneers, modern technology had diluted some of these dangers. But recent rapid changes, both to the islands and the behaviour of the animals that live here, meant they faced a whole new set of challenges.

Svalbard is heating up faster than anywhere else on the planet. The polar ice cap that used to creep down and encircle the islands each winter, cutting them off from the outside world, is shrinking at an unprecedented rate, with 2020 set to be one of the worst years on record, according to the Norwegian Meteorological Institute. In October, it reported that almost four million more kilometres of ice were missing compared to what was common in the 80s – an area ten times the size of Norway. Newly exposed areas of the ocean absorb far more heat than the naturally reflective ice, exacerbating the warming effects – part of a process known as polar amplification. The ice surrounding the Svalbard archipelago, which lies at the tail end of the Gulf Stream, is particularly vulnerable. As Kim Holmén, international director of the Norwegian Polar Institute, explains over video call: "The Arctic is warming twice as fast as the rest of the world. Within the Arctic, the area that is warming the most – almost twice as fast as the average for the Arctic – is Svalbard."

Disappearing sea ice and the plight of polar bears frequently make global headlines, but the world's worst warming is also upending the lives of the people, like Strøm, who call these islands home. In 2006, Longyearbyen, the largest settlement on the islands, was chosen as the site of the Global Seed Vault. Dubbed "The Doomsday Vault" by the media, the seedbank was built to help repopulate the world's crops in the event of environmental catastrophe. But in 2017, unseasonable rains caused the entrance hall to flood. In the space of a decade, it seemed the town had gone from ragnarök-proof refuge to the canary in the coalmine of the coming climate apocalypse.

When Strøm and Sorby launched their overwintering project, Hearts in the Ice, they weren't just trying to make polar history – they were warning that without drastic changes, there won't be much

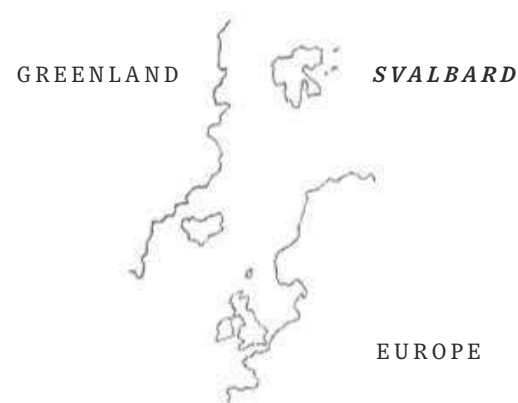
more polar history. Between them, the pair have half a century of hard-earned expedition experience. But with the environment around them changing so fast, old certainties are melting away. Dogs like Ettra would not normally be a target for polar bears, for example, but as their habitat and hunting grounds disappear, the animals are becoming more desperate in their search for food. Encounters with humans are on the rise, and bears are increasingly wandering into Longyearbyen itself, previously considered a safe zone.

One week before I was due to fly to Svalbard to meet Strøm and Sorby on their return from Bamsebu, Johan Jacobus Kootte, a 38-year-old manager at Longyearbyen's campsite, was attacked and killed in his tent, which was pitched just 100 metres from the airport. As a friend wrote in an online tribute, "he wasn't doing anything that hasn't been done safely there for 40 years".

Landing in Longyearbyen on a summer's day, with the sky a washed-out grey and the temperature around 5°C , it's not obvious why anyone would choose to live here. For centuries, very few people did. With no indigenous population, the islands were so sparsely inhabited that by the end of World War I, they were considered *terra nullius* – no man's land.

Today, the islands are governed by an agreement dating back to the post-war carve-up by the victors at Versailles. The Svalbard Treaty stipulates that while the territory is legally part of Norway, citizens of all signatory nations must be allowed to live and work on the islands. No country can use them for military purposes, and all have the right to engage in commercial activities. For most of the 20th century, that meant mining coal.

Although 46 nations have now signed the treaty – including Afghanistan, Iran and North Korea – in practice only two, Norway and the former USSR, have ever possessed the will or the cold-weather logistical wherewithal, to fully exercise their mining rights. Because of the archipelago's strategically sensitive location,



BELOW: HILDE FÅLUN STRØM (AND ETTRA). STRØM ALWAYS CARRIES A .44 MAGNUM TO FEND OFF POLAR BEARS



‘The climate crisis requires compassion and community, not competing one against another’

and Norway's membership of NATO, both governments subsidised their operations heavily, as a way of keeping civilian boots on the ground. Outside visitors were not encouraged. But in the 90s, when the Soviet Union collapsed and the world's appetite for coal cooled, the Norwegian government decided tourism might offer a better return on their investment, and the islands began to open up.

Svalbard's first full-service hotel, a 128-room building that was dismantled and shipped north in its entirety after the Lillehammer Winter Olympics, opened in 1995 – the same year a 28-year-old Norwegian with white-blond hair and an adventurous glint in her eye stepped off the plane to take up a job at one of the new tour operators in town.

Tall and athletic at 53, Hilde Fåln Strøm still exudes an untamed energy that leads Sorby, at one point, to compare her friend to a wild horse, but she talks with the steely self-confidence you'd associate with an experienced mountain guide. On trips beyond Longyearbyen's limits where a gun is an essential safety precaution, Strøm carries a .44 Magnum in a holster made from the pelt of a seal that she shot, skinned and embroidered herself.

Longyearbyen's Kulturhus, home to a library that's advertising a literature festival and a café that serves us lattes, didn't exist when Strøm first arrived. Back then, she remembers, the settlement was so small and male-dominated that "everyone knew there was a new girl in town". But as tourism grew, the town grew with it, with the new industry attracting a generation of young, international adventure-seekers who stayed

– drawn-in by the polar landscapes, the chance to earn Norwegian wages and the visa-free access of the Svalbard Treaty.

Today, Longyearbyen's year-round population averages around just 2,300, yet includes citizens of more than 50 countries. The town's third-largest population group is Thai, and 33 per cent of residents are non-Norwegian, a number bolstered by the more than 700 students and academics from 43 countries who conduct research at UNIS, the University Centre in Svalbard. Among these is Zdenka Sokolíčková, a Czech social anthropologist, who explains that while Longyearbyen is not entirely free of problems (not least, overtourism), xenophobia has never been one of them.

"It's a utopia," says DBC Pierre, the Booker Prize-winning author who comes on holiday to Svalbard every year. In a place this remote, he says, "people are free to be themselves. And people are naturally tolerant, I think. In Svalbard, it doesn't matter who lives over the hill, you know you have to help them if they're in trouble, and likewise they'll come and help you."

Occasionally, the outside world will intrude, in the shape of a sabre-rattling pronouncement from Moscow. But on the ground, the treaty's strict demilitarisation clause has held firm. For more than 40 years, Svalbard was a geopolitical anomaly – with Soviet and NATO citizens coexisting side-by-side just a few kilometres up the fjord from each other. Yet having seen off the threat of nuclear war with their neighbours, the people of this increasingly international community are now facing a new – but no less existential – challenge.



ads Forchhammer doesn't look like a harbinger of doom. If anything, his ruddy cheeks, silver beard and easy laugh suggest he should be delivering presents, not news of the impending apocalypse. But as we drive out of Longyearbyen into Adventdalen, the broad, glacial valley where he conducts the bulk of his fieldwork, the picture the professor of Arctic biology paints is a bleak one.

The rapid rise in average annual temperatures – between three and five degrees since 1971 – is causing dramatic changes in the vegetation, he explains. Svalbard is visibly greener in summer than it was just a few years ago. "We also have a shift in species, so plants or species which thrive better in warmer weather are now seen more frequently," he says. For some species, including Mads' main subject of study, the Svalbard reindeer, this has been a boon. "We have never had as many reindeer as we have now," he says.

The new carpet of vegetation makes Svalbard easier on the eyes in summer, but in the soil beneath the surface, things look more disturbing, as long-frozen micro-organisms begin to stir.

Forchhammer's colleague Sarah Strand, originally from California, has spent the past six years studying permafrost. In Adventdalen, her studies show that the active layer of permafrost, the section which thaws in summer and freezes in winter, is thickening by 1cm a year.

"When the active layer is frozen, there's not much happening in terms of microbes," she explains. "If you have stuff that's rotting, it won't be rotting when it's frozen." As more permafrost thaws, however, the rot spreads, with the potential to release vast quantities of





greenhouse gas, such as methane and CO₂.

Feedback loops where heating creates the conditions for further warming are one of the factors that make climate projections so difficult. But scientists agree that at some point these processes – permafrost thaw or polar amplification – are likely to lead to tipping points.

A 2019 report by the Norwegian Centre for Climate Services suggests that if global emissions aren't reduced, average air temperatures will be 7 to 10 degrees warmer on Svalbard by 2100.

Here, however, climate science isn't just a set of predictions in academic papers; it's something people see with their own eyes. Talk to anyone in Longyearbyen – even those rare few who, off the record, dispute the idea of manmade climate change – and they'll tell you it already rains more than it used to; that the snowmobile season is generally getting shorter; and the Isfjorden, or “ice fjord” on which Longyearbyen lies, hasn't lived up to its name since the winter of 2004-5.

And there other, deadly consequences.



TOP: LONGYEARBYEN'S AVALANCHE GUARD. ABOVE: CITIZEN SCIENTIST SUNNIVA SORBY. LEFT: BIOLOGIST MADS FORCHHAMMER



BELOW: SEASONAL SURGES OF ICE HAVE SHRUNK, LEAVING MORE EXPOSED SEAWATER AND UNFROZEN LAND





Strøm and her husband Steinar live in a terracotta-coloured house at the top end of road no. 230, in the oldest part of town. It's part of a long terrace that is frequently photographed by tourists, with each traditional A-frame dwelling connected to its multi-coloured neighbours by a flat-roofed, wooden entrance hall.

On the morning of December 19, 2015, the couple were at home, eating breakfast. It was the middle of the Arctic winter, and a heavy storm had battered the town all night, ripping the roof off one of the school buildings. Around 8am however, the wind died down, leaving behind a thick blanket of fresh snow. It was a Saturday just before Christmas and, despite the darkness, the children were getting excited.

Two doors down from Hilde and Steinar, a young family was preparing to go out. Two-year-old Nikoline Røkenes and her sister Pernille, three, were putting jackets on in the entrance hall, waiting impatiently for their parents to come out of the main house. At around 10.20am, the avalanche hit.

A huge slab of snow, some 200m wide, slid down the hillside, tumbling over itself in a deadly white torrent, four metres high in places. Twelve houses on the Strøms' road were swept clean away, with debris carried 80 metres downhill. Some of the A-frames remained intact enough to protect those inside, but the Røkenes' entrance hall splintered, as if it was made of matchsticks.

"I was the first at the site," remembers Strøm. "Me, Steinar, and one other man there maybe before us – in addition to the young couple, who were looking for their small girls." As the emergency services, and more of their fellow residents,

arrived to help in the desperate search for survivors, Strøm took care of the girls' mother. But avalanche snow sets like concrete, and two small children are hard to find when you don't even know where to start digging.

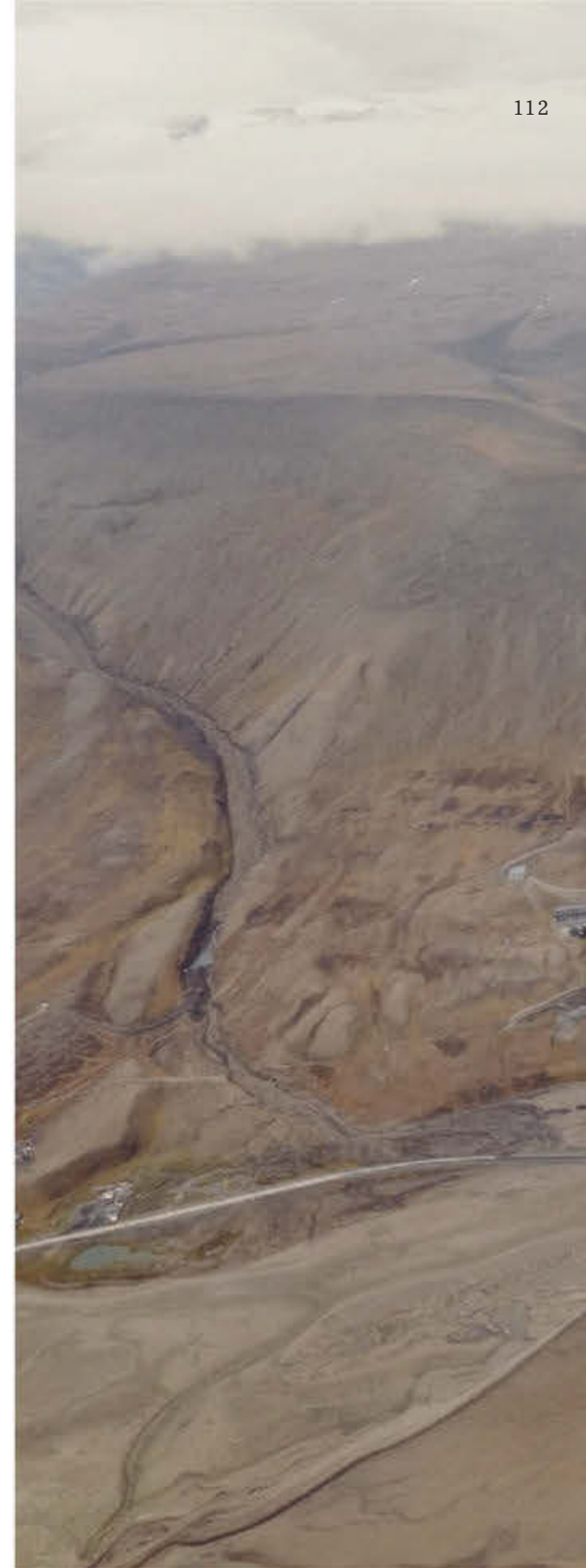
After an agonising two hours, rescuers eventually found Pernille, who had miraculously survived. But little Nikoline, who was pulled from the snow a few minutes before her sister, never regained consciousness. As she lay in the hospital, more tragic news filtered through. Atle Husby, a 42-year-old father of three, who taught at the school and played mandolin in the local bluegrass band, had also been killed.

The avalanche hit the small, self-reliant community hard. The physical scars remain visible to this day – the black soil where 12 homes once stood still is churned by the movement of diggers and salvage vehicles. On the hillside above, two gleaming rows of steel avalanche barriers, installed to ensure the tragedy is never repeated, serve as a constant visual reminder of the event. But there are deeper, mental scars too.

Four years after the avalanche struck, when Zdenka Sokolíčková, the Czech social anthropologist, first started interviewing long-term residents about life in Longyearbyen, several of them broke down. "Everybody knew that life in Svalbard was kind of dangerous, but people tended to believe that they were safe when they were at home in Longyearbyen," she says. "Realising that this was not the case hurt a lot."

There was comfort to be taken from the candlelit vigils, the moving memorial services and what Sokolíčková calls the "official discourse" of a community coming together. But beneath that, darker currents swirled. People pointed fingers, arguing about the complex causes of the avalanche and asking why they hadn't been better-protected. With the dangers of climate change apparently suddenly and horrifyingly real, community cohesion suffered. Longyearbyen, it seemed, was no longer the utopia some had imagined.

For Strøm, the trauma was a galvanizing force. The idea of spending a whole winter at Bamsebu was something she'd been mulling for a while. "But now, my dream of an overwintering went from something selfish, a point of experience, to something that I wanted to do to make a contribution," she says. "I wanted to raise awareness. But I didn't know how."



TOP: LONGYEARBYEN, POP. 2,300. ABOVE: METEOROLOGIST SIRI WIKSTRÖM AND PERMAFROST SCIENTIST SARAH STRAND. RIGHT: AN EISCAT RADAR DISH



and Sorby's stay meant they were perfectly positioned to support researchers working on data-driven studies. Where the hut's original occupants would have hunted with crude traps, Strøm and Sorby spent their days gathering evidence with sophisticated equipment. A DJI Mavic 2 drone, modified by Canadian company InDro Robotics, would fly preset patterns to record infrared imagery. This was fed back to researcher Eric Saczuk at BCIT, who uses multispectral analysis to map out the lichen which contributes to the "greening" effect observed by Mads Forchhammer. They also had a Fuji X-T3 DSLR for shooting long exposures of the Northern Lights for Liz McDonald, a space weather scientist at Nasa – and, on one occasion, to photograph a rocket launch.

There were blunt instruments, too: the hand auger used to take ice core samples for analysis back at UNIS, and perhaps the simplest, but most important tool of all – the Secchi disc. Strøm and Sorby would lower this black and white circular target into the ocean from their boat, recording the depth at which it disappeared in order to give Allison Cusick, a biological oceanographer at the SIO, vital data about phytoplankton populations.

"Phytoplankton don't do so well in warmer, fresher water," Sorby explained on one of the regular Zoom calls she and Strøm conducted with their scientific partners and classes of awestruck school children. "With the sea ice melting, and fresh water melting into salt water, they're not surviving." This, she says, is scary – not just because the micro-organisms are the building blocks of the entire ocean ecosystem, but because "they're also responsible for 70 per cent of the oxygen in the atmosphere – more than a rainforest."

Feeding data to climate scientists became a huge part of Strøm and Sorby's project. But the fact that they are, as Sorby modestly puts it, "two ordinary women", was arguably more important for their message. "We wanted to show that we can all make a contribution to climate science," Strøm explains. Sorby says they wanted "to speak to the young girls out there, but also the young boys, and say 'role models come in all shapes and sizes.'"

The hyper-masculine history of polar exploration, which glorifies gambles and the act of sticking your flag in somewhere first, features prominently in Svalbard lore. From the outset, Sorby says, they were determined to showcase a different way of doing things. "I feel that men show up in the world of exploration with more of their ego at stake," she says – but the leadership the climate crisis requires is the opposite. "It's about compassion, communication, and building community; not competing against one another."

For all the success of their collaboration, spending an entire year in two small rooms, with someone you've previously spent no more than two weeks with, is a daunting task – especially when those two small rooms are in an uninsulated, 90-year-old wooden hut and your nearest neighbours are a six-hour snowmobile ride away. Add in the lack of running water or a flushing toilet, and blizzards so strong that, on one occasion, they ripped the door off the hut – not to mention the risk of hypothermia, frostbite and polar bear attack – it's no wonder that things sometimes got a little tense.

Arguments were usually sparked by small disagreements, the pair say. When getting dressed in all the layers needed to go outside takes ten minutes, it's easy to be frustrated if your partner takes 15. Because of the bears, looking out for each other was essential at all times. "So I mean, we did everything together," Strøm says – even walking down to the shore to dispose of their waste when one of them

he answer came to her the following September, at a travel trade conference in Alaska. Like Strøm, 59-year-old Sunniva Sorby, a Canadian of Norwegian descent, has spent a large part of her career in the polar regions – albeit in the south.

Introduced by a mutual friend, the pair were queueing for coffee when Sorby gasped. "Oh my god. You've got the same ring!" With its looped polar bear design, made by an Inuit artist on the western coast of Greenland, the ring instantly marked Strøm out as someone special to Sorby, who combines the determined optimism of her hero, Ernest Shackleton, with a tendency towards the spiritual.

Strøm remembers being slightly starstruck. Sorby had been part of the first female team to ski to the South Pole, in 1993. "I thought that was pretty cool," Strøm says, and the two of them hit it off.

The initial idea for the overwintering might have been Strøm's, but it was when Sorby came on board that it morphed into the multi-pronged project that Hearts in the Ice became, encompassing activism, education and research. "I inspired her, and she inspired me," says Sorby.

Sorby was also instrumental in pushing the idea of citizen science. "There is a word for it in Norwegian, *folke forsker*," explains Strøm. Sorby had also worked with scientists from Nasa, the Scripps Institution of Oceanography (SIO), and the British Columbia Institute of Technology (BCIT). When the two women laid out their plans, researchers jumped at the chance to send them assignments.

The men who built Bamsebu in the 1930s might have picked the location for fur trapping, but its remoteness, the absence of light pollution and the length of Strøm



went to the toilet. “There was no privacy. We were like an old married couple.”

But as the generations living on Svalbard before them had discovered, when the simple acts needed to stay alive – creating heat, making food, sourcing water – take up to four hours a day, friendship and co-operation become the default human emotions. And if they ever doubted their decision, the questions of the nearly 10,000 school children who dialled in to hear them speak over the course of the winter quickly reminded them of the importance of their mission. “There’s a good saying in Norwegian, ‘kunnskap endrer atferd’, which means something like ‘knowledge changes behaviour’,” says Strøm. Once you know, how can you not agitate for change?

Much of the conversation around climate change on Svalbard revolves around that idea: that these islands, and the microcosm of the international

community that calls them home, could serve as an example for the rest of the world. Local engineers make the case that if renewables can work in such an extreme environment, they can work anywhere. Academics argue that the open-door immigration policy promotes collaborative research, and tour operators suggest that if only more people could see the damage with their own eyes, they too would become climate advocates.

Yet despite the growing numbers of VIP visitors, decisive international action of the kind required to spare this archipelago and its inhabitants from the most apocalyptic scenarios remains elusive. There’s every chance the example set here could be a far bleaker one.

On July 25, 2020, the Norwegian Meteorological Institute recorded the hottest temperature ever registered on Svalbard: 21.7°C. The following morning, miners from the Store Norske

coal company arrived at work to find a melting glacier had flooded the mine.

Concern cuts right across Svalbard society, according to Morten Wedege, head of environmental protection at the Sysselmannen, the Governor’s Office. Smartly dressed, with grey hair and a neat beard, he explains that it doesn’t really matter how well the community here responds to the climate crisis – it is decisions made in far-flung capitals that will ultimately decide their fate.

“I am very, very worried about how Svalbard will look in 20 years,” he says. “What will there be left to see? Even if we stop all emissions today, you have a delayed effect. The snowball is rolling.”

On the morning before Strøm is due to leave Longyearbyen for a break on the mainland, I swing by her house to say goodbye. Under the eaves of the entrance hall, hanging just out of Ettra’s reach, are two bloody sides of raw, red meat – the result of a reindeer hunt. In the kitchen, Steinar is quietly butchering the rest, while the living room floor is covered in expedition gear from Bamsebu. Rifle cases lie open by the radiator, backpacks overflow in the hallway, and there are boots drying in a corner. She’ll leave some of the gear packed-up, Strøm says, because she and Sorby are going back.

“It’s many things,” says Strøm, when I ask why. “But mostly it’s where we see we can make an impact. How much stronger are our voices from Bamsebu, than from here in civilization?”

Events beyond Svalbard, Sorby later explains over the phone from Montreal, have only served to highlight the urgency of their message. When they left for Bamsebu, wildfires raged in Australia. When they came back, California was ablaze. “Imagine Mother Nature as a body with different organs,” she says. “In one part of the world her lungs are failing. In another part her liver is not functioning. In another her heart is having trouble beating. Once you understand that all her systems are crashing, you realise that ‘holy shit, it’s not tomorrow, it’s now.’”

They’re under no illusions that it will be tough, but they’re nothing if not tenacious. “I’m not Mother Theresa, and neither is Hilde,” says Sorby. “We’re simply trying to show up, and do our part.” Or as Strøm puts it, her mouth set in a steadfast smile: “The climate crisis isn’t taking a break, so neither are we.” ■

Tristan Kennedy is a British journalist based in Dublin, specialising in environmental issues. Hilde Fållun Strøm and Sunniva Sorby’s book, Hearts in the Ice, can be pre-ordered at heartsintheice.com

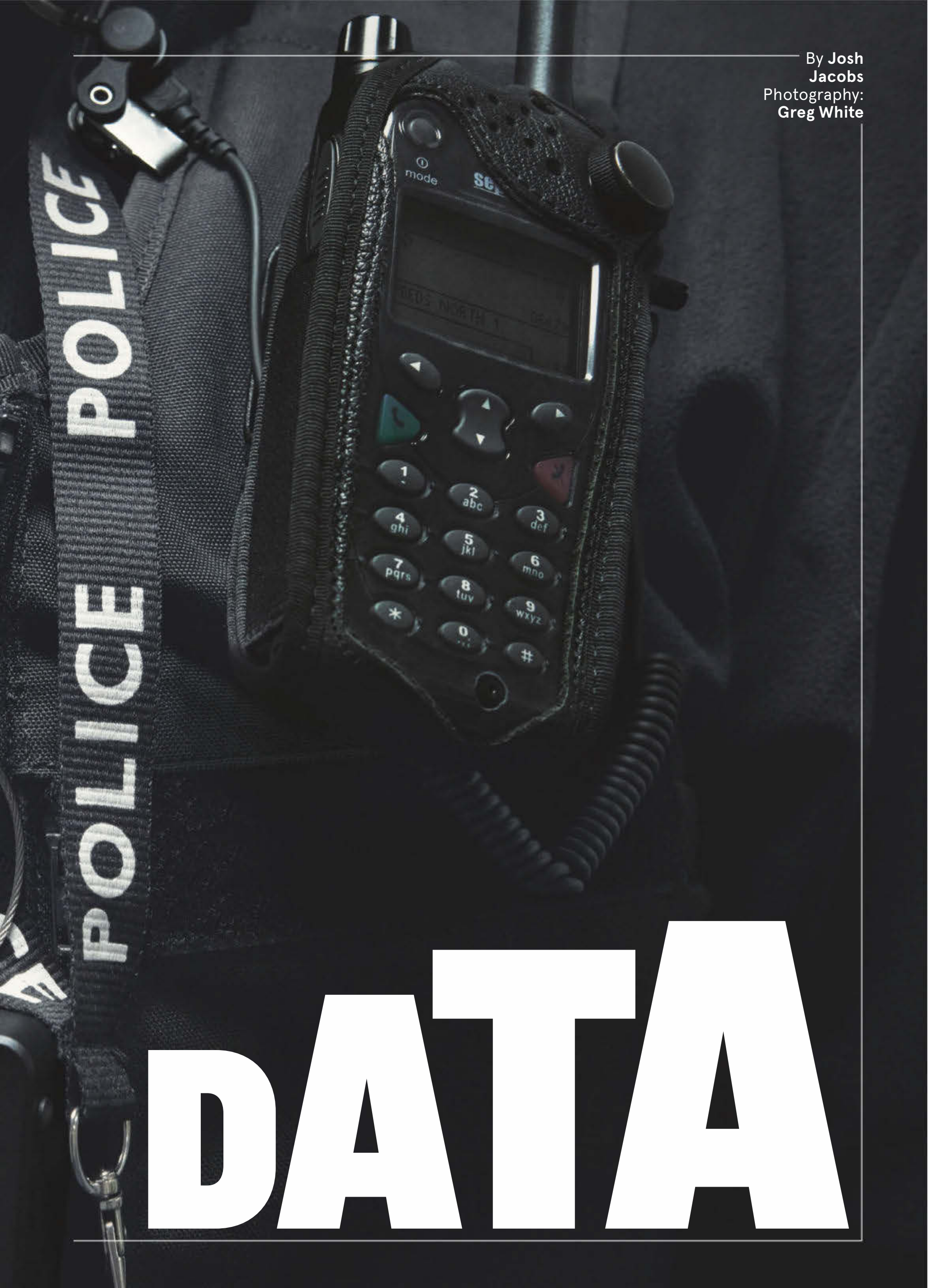


Policing is broken. Could scientific thinking and an evidence-based approach make it more just and effective for all?

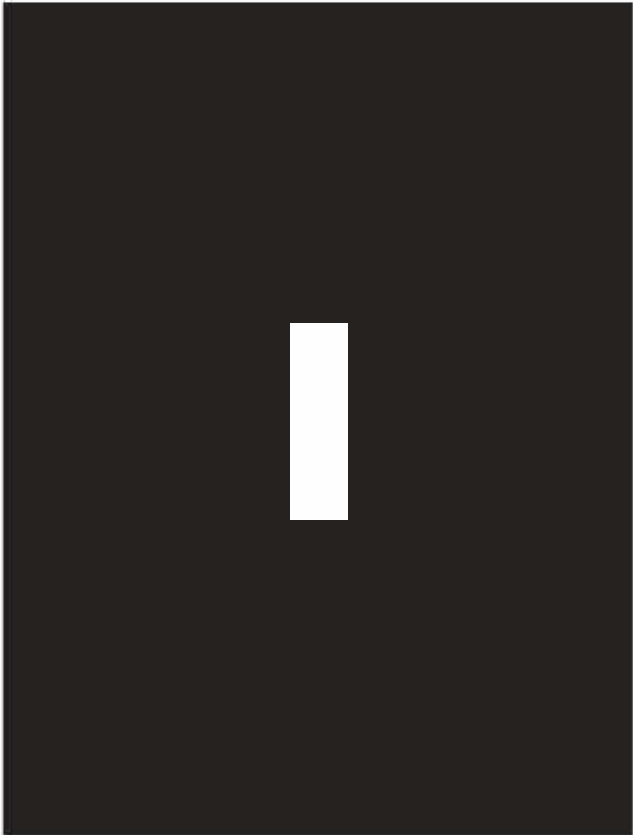
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LAW &

By Josh
Jacobs
Photography:
Greg White



DATA



n December 2013, Gillian Routledge, a police analyst in Durham, received a surprising phone call from her boss. “Do you fancy a master’s from Cambridge?” Mike Barton, then Durham’s police chief, asked. Two decades after she had last been at university, she packed her bags and set off.

Barton was on a mission to train his police to think scientifically and use rigorously gathered evidence to decide how best to limit crime. At Cambridge, Routledge would help to design one of the UK’s most radical policing experiments as part of her criminology master’s thesis. Hundreds of people arrested for low-level offenses, ranging from assault and burglary to fraud and child neglect, would have their futures decided by chance.

Half of them would face traditional prosecution; the other half would be offered a four-month deferred prosecution programme called Checkpoint. They’d undergo personalised treatment plans – meeting their victims, working with psychologists, undertaking community work. Routledge and colleagues wanted to see if an alternative to criminal prosecution could reduce reoffending.

In spring 2015, Durham police began testing Checkpoint, and in summer 2016 they launched a 20-month trial. This was a randomised controlled experiment, a method typically used in medicine to test new drugs, where groups are randomly given different treatments to assess their efficacy.

The trial was targeted specifically at people who were predicted to be at “medium” risk of reoffending. Officers identified potential participants with the help of a machine-learning algorithm called the Harm Assessment Risk Tool (HART), designed by Cambridge professor Geoffrey Barnes, Routledge’s thesis supervisor, which forecasts how likely someone is to reoffend in the next two years based on 34 variables ranging from age to criminal history. When they found someone eligible for the trial, they decided whether they should be offered Checkpoint or face conven-

tional prosecution using a computer randomiser – akin to electronically flipping a coin.

Some police officers struggled with the arbitrariness of the randomiser. When they knocked on Barton’s door complaining it was unfair to shuffle people’s fates for an experiment, he would patiently tell them they needed to think long term – to seek evidence about better ways of policing.

For the police running it, Checkpoint is a clear sign that not prosecuting certain people can reduce cycles of crime. Final results were still under peer review at time of publication, but Durham police data showed 15 per cent of people referred to Checkpoint reoffended during the four-month rehabilitation programme and around 37 per cent in the following two years – compared, respectively, with 26 per cent and 47 per cent of people in the control group. More than 2,600 people have now completed Checkpoint, and for every 1,000 people who pass through it, Durham estimates it saves £2 million in reduced crime. Several other UK police forces are rolling out similar initiatives.

Checkpoint is among dozens of policing experiments spawned in the past decade in a small department of the University of Cambridge called the Jerry Lee Centre of Experimental Criminology. The centre is run by Lawrence (“Larry”) Sherman, an American professor who believes that unleashing trials live on our streets can radically transform policing. Aged 71, Sherman begins his day with a morning exercise routine which could challenge many people half his age; a claimed 300 push-ups (“in batches of 100”), then a 6km run.

Over the last 50 years, Sherman has worked on trials around the US, UK, Australia and beyond. His field, called evidence-based policing, aims to bring a scientific approach to the foundation of policing – with rigorous experiments to test innovative ways to reduce crime and adapt policing tactics based on constantly-evolving evidence. Each year he trains more than 100 senior officers from around the world, who come to study his criminology master’s course. He also helps to design and analyse experiments run by students and colleagues. His department’s recent trials have included comparing patrols of police civilians (community support officers) with those of fully-fledged officers, and randomly allocating police armed with TASERs on different shifts in London.

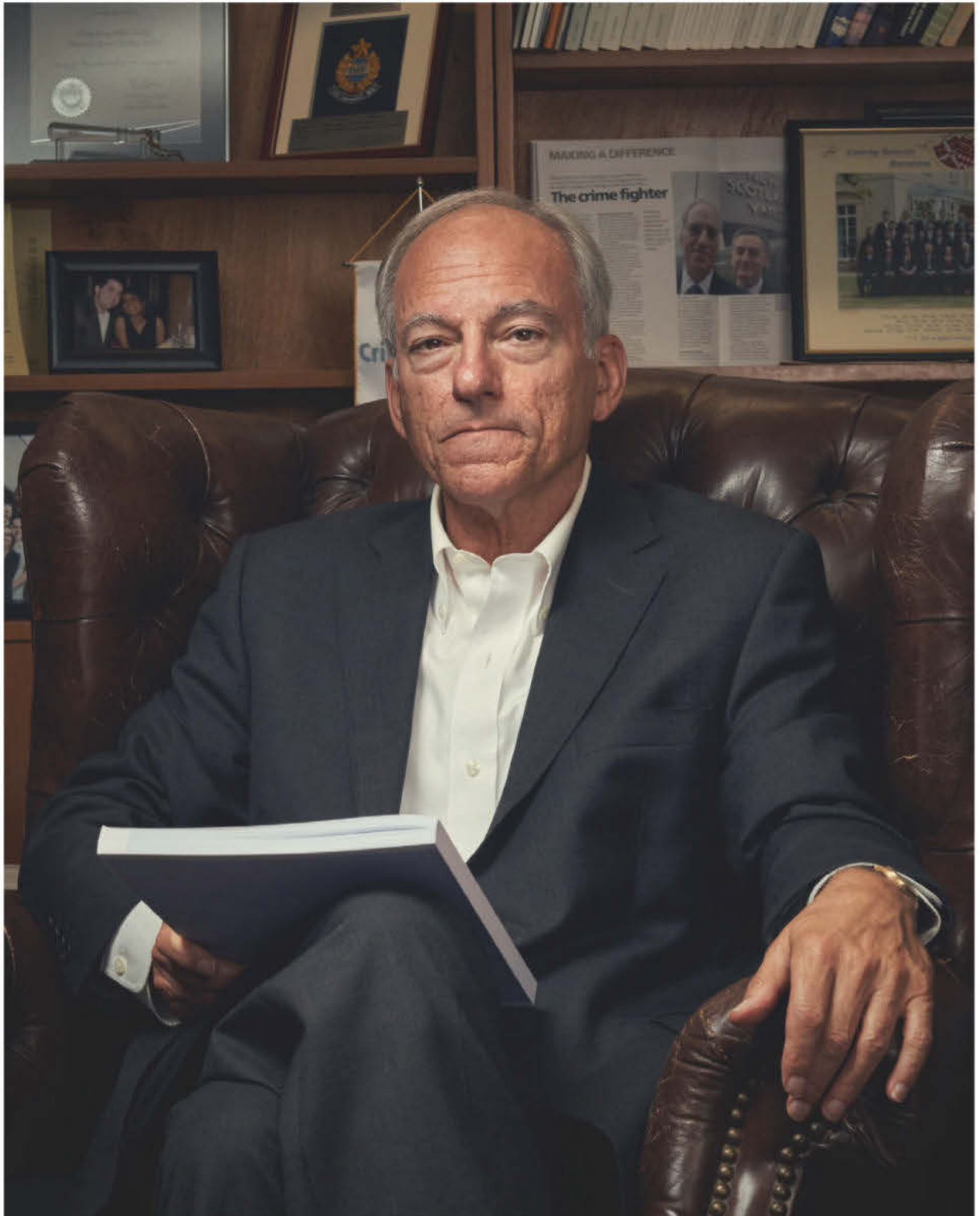
In Sherman’s view, police too often act on instinct and hunches rather than on the basis of evidence. He describes policing like medicine of the past, before the field was reshaped by randomised trials. Sherman has accused British police of treating computers like “electronic filing cabinets” and feels officers over-rely on arresting people, even when this is counterproductive. “The police are responding to too many cases where they’re not needed and therefore aren’t available to proactively identify who is at greatest risk of serious harm and to intervene with those victims, offenders and places,” he says. “So if we could stop doing a lot of the senseless errands [that

Right: Lawrence Sherman, director of the Jerry Lee Centre of Experimental Criminology

DATA INSIGHT #1
TASERs cause aggression

A randomised controlled trial found that London police officers equipped with TASERs used force 48 per cent more often than unarmed officers (even though they usually did not use the TASER). They were also more likely to be assaulted. Researchers suggest the visual cue of the TASER leads to increased aggression.

In Lawrence Sherman's view, police too often act on instinct and hunches, rather than on the basis of evidence. He describes policing like medicine of the past, before the field was reshaped by randomised trials





Right: Justice Tankebe, a Cambridge professor focused on police and state legitimacy

officers run] and start investing much more time in planning where police can do the most good based on statistical analyses, we would have a much safer population as well as a healthier one.”

Sherman was born in New York in 1949 to a Baptist minister mother and a father who worked for the YMCA. His parents raised him with a commitment to social justice and community activism. He recalls them joining Martin Luther King’s 1963 march to the Lincoln Memorial, where King called for an end to racism and economic and civil equality. Sherman’s teenage years were a period of particular racial tension in America, including police brutality towards civil rights activists and the failure to protect Black communities who were lynched and attacked. The teenage Sherman was captivated by the police’s potential to defend society’s vulnerable, but also its capacity to maltreat and abuse when its power is unchecked.

When he finished university in 1970, Sherman took up a national fellowship with the New York City police department. His first job focused on developing neighbourhood policing strategies, and he also joined sting operations to target corrupt officers. As violent crime rose around the US in the 1970s and 1980s, a view spread that police were powerless to stop crime – a philosophy known as “nothing works”. Sherman didn’t agree. Policing wasn’t condemned to fail, he believed; they were simply going about things the wrong way.

A few years after finishing a PhD in sociology in 1976, he got a lucky break. His former boss from New York, Tony Bouza, had taken charge of the Minneapolis police department and let Sherman start his own “laboratory”, running a series of trials across the city. (The same police department is now embroiled in charges of endemic racism; former Minneapolis officers are charged in relation to the death of George Floyd in 2020.)

In one of the first trials Sherman ran, launched in 1981, a group of officers was asked to use different

approaches to misdemeanour domestic violence crimes: arrests, mediation or sending suspects away from home for a few hours. Finding that those who were arrested reoffended less over the next six months than the other groups, the experiment helped to drive new laws requiring mandatory arrest for domestic violence across the US.

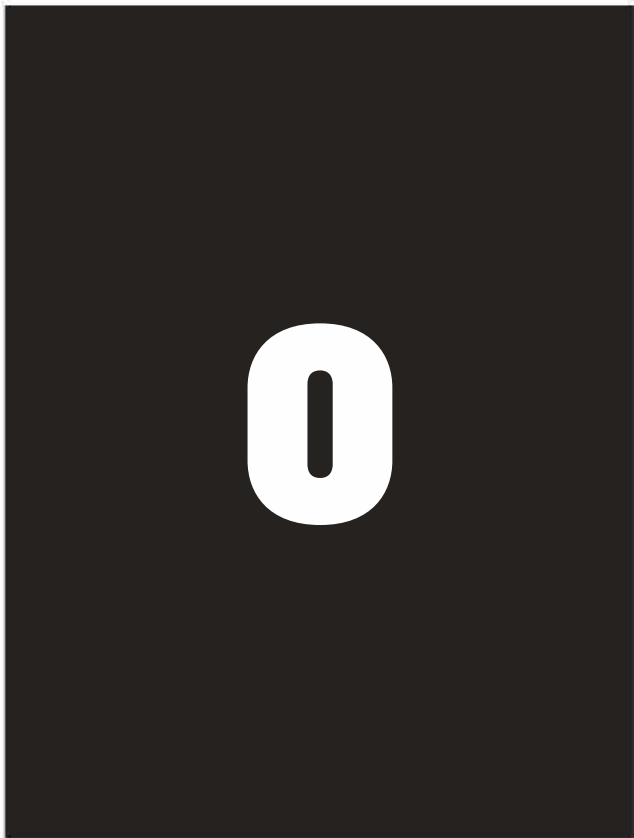
Besides domestic violence, Sherman spent many of his early years investigating the mysteries of crime concentration. In an early 1990s trial targeting illegal guns in Kansas City, Missouri, he identified an 80-square-block area, called beat 144, with a homicide rate 20 times the national average and a high number of drive-by shootings. In a bid to cut shootings, four officers spent around five hours a night over 200 nights patrolling, including stopping vehicles where there were legal grounds for doing so. Following the trial – which wasn’t a rigorous randomised experiment – there were 49 per cent fewer gun crimes in beat 144, even as crime remained at high levels across the rest of the city, while local community surveys suggested people were less fearful of crime. When the results were published, Sherman recalls receiving calls from police around the US interested in testing similar approaches. Writing up the trial, however, he noted that intensified patrols like those in beat 144 – whose residents were overwhelmingly from minority backgrounds – cannot be arbitrary and should be carefully considered.

In the late 1990s, on a flight to launch an experiment in Australia, Sherman had an epiphany. He began reading a book he’d stumbled across about the rise of evidence-based medicine: how running randomised experiments, ranking hospitals by death rates and pushing doctors to follow research had revolutionised healthcare. “That’s exactly what we need in policing,” he thought to himself. Shortly afterwards, in 1998, he delivered an impassioned speech to a Washington think tank, announcing the birth of evidence-based policing.

DATA INSIGHT #2

Stop and search inequality

From July to September 2020, Black men aged 18-24 were on average 19 times more likely to be stopped and searched in London compared to the population as a whole. The most common reason for all searches was to look for drugs; 76 per cent of all searches resulted in no further action.



n a sunny Thursday in September 2020, I join Sherman in Cambridge. In a large lecture hall, a few dozen police officers attentively take notes as Sherman and colleagues speak. Stacey Rothwell, an officer from Kent, joins Sherman on stage to explain her master's thesis: a randomised experiment with officers responding by phone, rather than in person, to certain non-urgent 999 calls. Such calls, she says, would be crimes that would not necessarily elicit an immediate physical response: they have included reported thefts, sexting offenses and someone threatening to burn down a victim's home and kill them (victims have a choice over participating in the experiment).

After Sherman speaks, he walks around the room offering a microphone to students; all seem to agree that policing needs to be more intelligence-led, more proactive and founded in evidence. One London officer I speak to, who has recently started Sherman's course, says he is enjoying it but is disappointed to be missing a major raid by his team that morning; colleagues found guns, drugs and two suspected victims of slavery.

After lunch in Sherman's Cambridge college dining room, I head outside to the college garden, where I meet some of his Ph.D students, and we chat about race and policing. Since I began reporting on Sherman in early 2020, protesters around the world took to the streets in anger at police killings of Black Americans including Breonna Taylor and George Floyd, but also at policing more broadly – at how it seems that officers too often compound, rather than alleviate, society's racial inequities. In the UK, the House of Commons Home Affairs committee has launched an investigation into racial disparities in policing, including allegations of institutional racism.

Justice Tankebe, a Cambridge professor focusing on police and state legitimacy, says that calls to reform the police aren't necessarily in conflict with evidence-based policing (though

some are calling to abolish policing as we know it entirely.) Tankebe argues that critics want policing to be less arbitrary, for officers to work with communities to gain legitimacy, and for them to protect minorities. "The issue is that the police have failed to respond to people's legitimate expectations," he says. "People are saying, 'The police are becoming part of the problem rather than the solution.'"

"If you look at it that way," he adds, "evidence-based policing may even be part of the answer to critics who call for defunding police." For Tankebe, this is a moral obligation: to show which policing methods are helpful and which are causing more damage to the people police are supposed to serve.

As Sherman sees it, officers spend too much time rushing out to crimes that have already happened, or attending minor offenses – such as George Floyd's alleged possession of a counterfeit banknote. Instead, they should focus on preventing high-harm crimes through prediction and targeting. Just as doctors have the tradition of the Hippocratic Oath – "first, do no harm" – he believes officers should be schooled in Hippocratic policing: only using arrests or searches where there is evidence it will prevent harm. "We want as little policing as possible," Sherman says, "like we want as little surgery as possible. The question is: when will we kill people by not giving them surgery?"

DATA INSIGHT #3
**Racial inequality
in homicide risk**

A 2020 study based on data from the Office of National Statistics and the census found that Black people were 5.2 times more likely to be a victim of homicide than white people in England and Wales in 2018/2019. Among those aged 16-24, the homicide rate was 24 times higher for Black people than white people.



In 2014, following the fatal shooting of Michael Brown, a Black teenager, by a white police officer in Ferguson, Missouri, Sherman was part of Barack Obama’s Task Force on police reform. The officer involved was eventually judged to have acted in self defence, but one of Sherman’s suggestions after the incident was that US states create independent inspectorates with the power to punish officers and departments that had been identified as abusive. His ideas were not adopted, but recently he has pushed for reforms including turning predictive policing on to the police themselves, using algorithms to identify rogue officers. He says he is deeply motivated to use science and technology to make policing fairer, “taking a long view that is steeped in the history of the racist societies in which all modern policing has [operated].”

Cynthia Lum, a former Baltimore police officer who now runs the Center for Evidence-Based Crime Policy at George Mason University, says that recent decisions by some US police departments

to restrict chokeholds and neck restraints are “low-hanging fruit”. Many problems are harder to address, such as how to create real accountability and how to prevent crime without fuelling racial disproportionalities in the criminal justice system.

Sherman also adds that while some minority communities are overpoliced, they are also under-served by police and the criminal justice system, and are disproportionately victims of crime. In a November 2020 paper, Sherman and colleagues show that the most recent (2018-19) homicide rate for UK 16-24-year-olds is 24 times higher for Black than for white people. A fairer policing system, he says, would need to help address such disparities.

As Tracie Keese, senior vice president of the Center for Policing Equity, sees it, the goal is to find “the sweet spot where we’re not overburdening one community, yet we are providing [services] differently” in different places. Dismantling the police could hurt the poorest communities, including many minorities. “I’m not satisfied with just saying

While some are convinced by Sherman’s promise of replacing gut instinct with evidence, others in the force feel he dismisses the human dimensions of policing, and scorns police officers’ experience



Left: Vincent Harinam, one of Sherman's Ph.D students at Cambridge's Institute of Criminology

that's the collateral damage," she says. Keesee is calling to rethink the role of officers, acknowledge racial injustices, and spread new models of public safety informed by local people.

Experiments, evidence and technology alone won't solve the racial and economic inequities that persist across society. Lum and others are confident that, when carefully used, evidence-based policing's toolbox – including experiments to understand which policing tactics work and which don't – is important for deciding a new model of policing. One thing she's sure of: policing mainly through arrests and force is not the way forward.

Keesee says that research needs to be coupled with action and political will. For several of the communities she works with, there is impatience and pain. "They're not interested in another study," she says. "We know what it's going to take to do this," she adds, referring to the need to reform policing, invest in deprived areas and focus on serious crimes. "The question is: are we going to?"



DATA INSIGHT #4

Phantom policing

An experiment on the London Underground found that brief patrols reduce crime, even when police are not present. When British Transport Police patrolled selected stations in 15-minute "doses", calls to police from these stations reduced by 21 per cent, with the reduction mainly noticeable when police weren't actually there.



core tenet of Sherman's approach is detecting and focusing on crime "hotspots" – areas with high levels of violent crime that can be as small as a single address or intersection. Sherman's colleague and former British police chief Peter Neyroud says that policing such hotspots requires "keyhole surgery", but that most police are "still cutting the whole body open... They're not scientific about it, quite often they're wrong, and they frequently don't know the real high-crime places."

Sherman believes that over-patrolling wide areas hasn't only cost the police legitimacy, but is also an ineffective way to stop crime. Many, including a senior minority officer in the US I spoke with, see the widespread use of tactics like stop and search as racist and illegal. By focusing instead on small hotspots with a variety of different approaches, Sherman believes police can limit

indiscriminate profiling as well as reduce violent crime. Tankebe cautions that data for identifying hotspots mustn't come only from police themselves, since this creates a "self-fulfilling prophecy": some areas may appear to have higher levels of crime not because more offenses are necessarily being committed, but because they have been historically over-policed.

In the UK, Sherman has begun applying his hotspot approach to knife crime, which rose by seven per cent in 2019 in England and Wales to the highest levels recorded. In 2019, he supervised one of his Cambridge students, then a London homicide detective called John Massey, who pinpointed the locations of thousands of non-fatal knife attacks around the capital in one year and of lethal stabbings the following year, in search of patterns. They found the majority of knife murders happened in neighbourhoods that had seen at least one non-lethal stabbing the year before. Clusters of streets which recorded six or more injuries the first year were 15 times more likely to see a homicide in the second year than areas which recorded no knife assaults (the majority of the city).

National newspapers covered the work with dramatic headlines suggesting a new way to tackle Britain's violent crime epidemic. Massey has since trained London police to better understand where knife assaults are concentrated, but for Sherman, this isn't enough. To put the research into practice, he wants an experiment with randomly surging patrols in different hotspots over different time periods, or to test other approaches such as chaperoning children to schools or installing knife arches at school entries in the high-risk neighbourhoods, to see if this can reduce deaths.

Sherman is perhaps most enthusiastic about the counterintuitive prospect that policing less, rather than more, could reduce crime. He sees powerful potential for improving relations in over-policed neighbourhoods, as well as helping forces

save money. Several of his department's recent experiments have been centred around this idea. They include a trial across London train stations published in early 2020, in which a pair of officers were assigned to patrol half of London's most high-crime Underground platforms in 15-minute bursts; reported crime dropped by 28 per cent on these platforms, with reductions occurring mostly when the police weren't actually present. Sherman and his team call this a "phantom effect", with a brief appearance by police officers resulting in a residual benefit after they leave.

One of the biggest tests of "minimalist policing" took place over 248 days in western Australia in an experiment published in summer 2020. It was run by Sherman's colleague Geoffrey Barnes, with Australian police. The experiment gave officers GPS-enabled phones to track their movements. They were randomly assigned between three and seven neighbourhoods to patrol each day, from a list of 15 high-violence districts in Perth; the remaining neighbourhoods were left without extra officers for up to 20 days. After one mere 15-minute patrol (or "treatment day", as Sherman calls them), there was a notable drop in crime for four days afterwards – suggesting that the threat of a police visit may be as much of a deterrent in some cases as another patrol. (The effect doesn't last: on the fifth day, crime would surge by an average of 66 per cent.)

The next stage of this research launched in October in Bedfordshire, UK. In a project managed by Michelle Leggetter, another alum of Sherman's course, police are working with the Cambridge Centre for Evidence Based Policing – Sherman's for-profit company, which he runs with Heather Strang, his colleague and wife, and which sells products including consultancy and online tutorials – to run a new experiment. For three months, Bedfordshire officers will patrol seven neighbourhoods on foot for around 20 minutes each day; the list will be shuffled randomly daily, from a group of 21 neighbourhoods with high rates of serious weapons crimes involving young people.

The team want to find the optimal gap between police patrols – an equivalent to Perth's four-day "sweet spot" showing how frequently (or rarely) they should visit neighbourhoods to reduce violent crime. They will run the experiment's second phase in 2021: an alarm system linked to police radios will alert the control room to dispatch officers to neighbourhoods when the "sweet spot" period is about to expire and officers haven't visited.

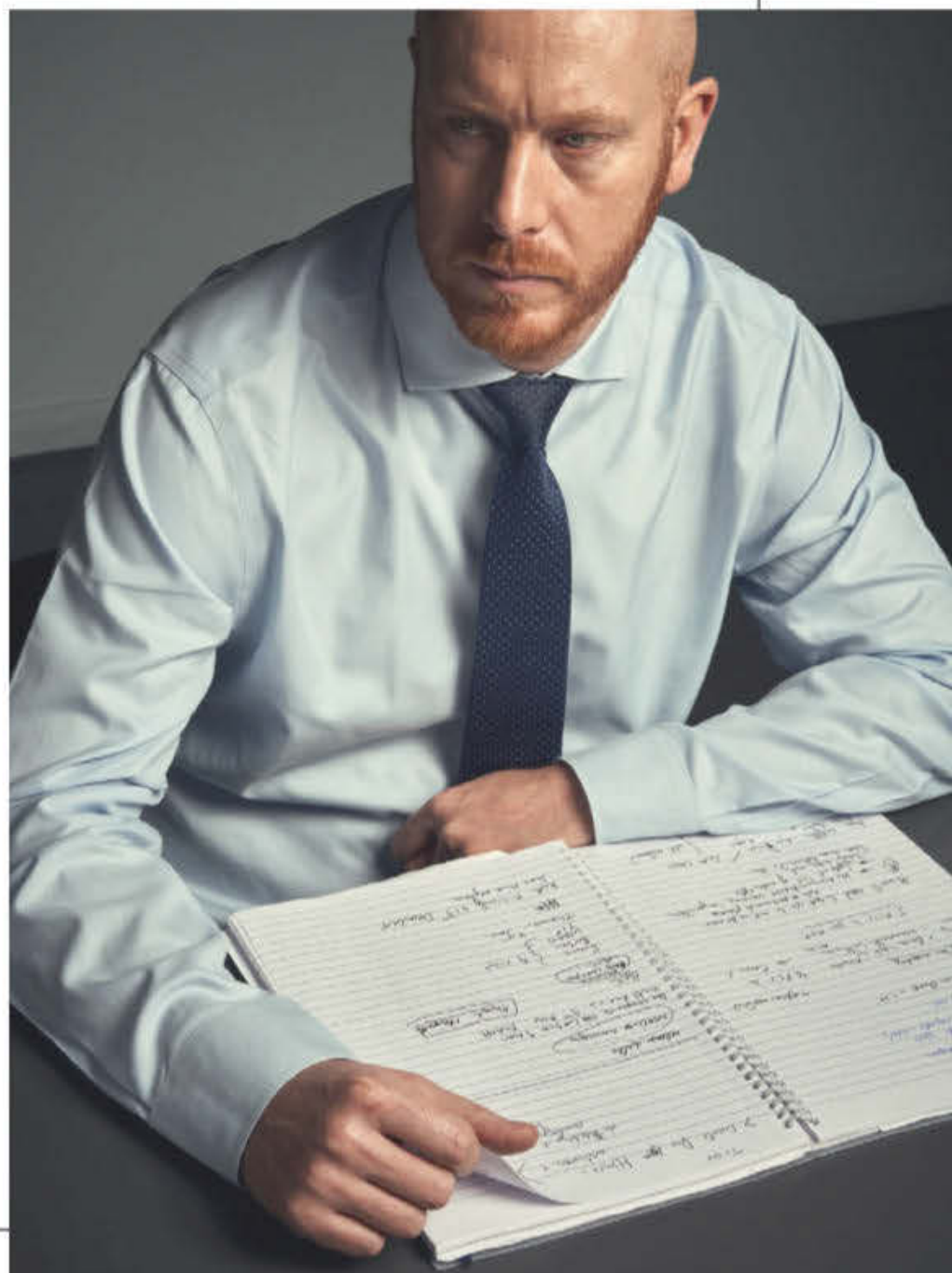
If they achieve similar results in Bedfordshire and elsewhere, Sherman is hopeful that the notion of policing less often, but in a more targeted way, will proliferate. One potential objection is that people seeking to break laws could learn policing patterns, but Sherman insists the patrols can be sufficiently randomised so that they can't be guessed. Matthew Bland, a Cambridge researcher working on the Bedfordshire experiment, hypothesises that targeting crime hotspots in this way could reduce harm from serious assaults by up to 20 per cent across the county.

S

Sherman's early work on domestic violence

remains among his most controversial, and shows the limits of individual experiments. His subsequent trials suggest that while arrests may reduce repeat offending among employed suspects, they can fuel further offenses in unemployed suspects. Arrests may also harm victims. In 2014, he ran a 23-year

Right: Michelle Leggetter, project Manager of Bedfordshire Police's hotspots experiment.
Below: detective superintendent John Massey





DATA INSIGHT #5

Knife crime hotspots

An analysis of knife crime data found that, of 2,781 London neighbourhoods that reported no knife crime in one year, only one per cent experienced a homicide the following year.

But of the 41 areas that had six or more knife injuries in the first year, 15 per cent of these had a homicide the next. Focusing on hotspots of non-fatal crime could therefore reduce deaths.

follow-up to an experiment and found that partners of those arrested on misdemeanour domestic abuse charges were 64 per cent more likely to die early from stress-induced conditions including heart disease than those whose partners were warned and allowed to stay at home. African-American domestic abuse victims were 98 per cent more likely to die early when partners were arrested.

The example of domestic violence also demonstrates a wider challenge for Sherman's field: how to spread evidence-based conclusions when they clash with political and public opinion – when people feel that a particular approach is required even where it doesn't necessarily reduce crime or lead to the best outcome for victims. Sherman has pushed for changes to mandatory arrest laws for domestic violence in the US and UK for decades with little success. "When you talk to police chiefs even today, with all the subtlety and complexity, they still feel vehemently that they don't care about the research," says Linda Mills, a domestic violence expert and public policy professor at New York University who has worked with Sherman on randomised experiments. "They are clear they are doing something [for victims] and they are doing the right thing in their community."

While some officers are convinced by his promise of replacing gut instinct with evidence, others feel he dismisses the human dimensions of policing and scorns officers' experience. Barnes recalls that during a talk Sherman once gave to Australian police, many officers were enthusiastic, but a substantial group seemed furious.

When Sherman's team have tried to run experiments, they've at times encountered challenges: British police pressing randomisers repeatedly to get the answers they want, for example, or officers in Trinidad reluctant to turn on their body cameras during experiments, seeing the request as an intrusion. Some of Sherman's students are dismissed as elitist, or mocked when they try to

push evidence in their forces. "We don't want to hear any more about your Cambridge experiences," one British officer recalls a colleague saying.

Even police who support Sherman's experiments recognise that they can carry risks. There's the chance people could be injured or killed in neighbourhoods with fewer patrols, as well as concerns over the justice of experimenting on certain areas and not others. Sherman is all too aware of the dangers, both physical and political, noting that police chiefs can be scared by his suggestions and that explaining them can be challenging. "Why are you allowing those people to die?" he says, imitating questions people might ask. "Oh, some crazy professor at Cambridge wants us to do it."

There are also fears around the technological aspects of some criminal justice experiments. One is that predictive algorithms can be opaque, unaccountable and may perpetuate social and racial biases – especially if trained using historical police data. A 2016 ProPublica investigation showed that an algorithm used in courtrooms to help guide judges' decisions in several US states discriminated against Black people. Some civil rights groups and academics were fearful that the HART algorithm in Durham could discriminate against people living in poorer areas, prompting postcodes to be removed from the data set.

Barnes, who designed HART and has helped build forecasting tools to predict fatal car crashes, among other things, acknowledges that algorithms use millions of data points and it may be hard to understand their decisions. But he believes police officers' own biases can be harder to change, and that using carefully-designed algorithms can provide accurate and consistent predictions to guide human decisions. "One real frustration is everyone wants to compare the results to perfection," Barnes says. "We didn't start with perfection, we started with human judgment."

Sherman believes that medicine's history has instructive tales for the future of policing. As Sherman has pointed out, Ignaz Semmelweis, the doctor who discovered that hand-washing could reduce deaths in childbirth, was ridiculed. The American College of Surgeons felt so threatened by the first performance rankings of US hospitals in 1919 that they scorched the report in the furnace of the New York hotel where they had convened. "Science is like that," says Barnes, who recently became deputy director of the Metropolitan Police's strategic insights unit. "It starts out with lots of petty jealousies. The police are maybe, at best, 20 years into this, and that is being generous."

Sherman is confident that his work chimes with the scientific currents of our age and remains the most effective path to a better, more just policing system. He plans to spend many more years on this quest, despite having recently celebrated his 71st birthday. "Eighty is the new 50," he says. "I feel like I just got started. There is so much to do and more opportunity to do it than ever before." ■

Josh Jacobs is a journalist based in London

POWER

RO

A Swiss underground lab is trying to unlock the clean energy potential of geothermal heat - without causing an earthquake

By Sarah Freeman

OK

Photography: Felix Wey

Left & above: the Rotondo granite of the Bedretto tunnel. The same rock, deep in the Earth, can hold vast amounts of geothermal energy

Burrowed 1.5km beneath a valley in Ticino, a region of southern Switzerland close to the Italian border, the Bedretto Underground Laboratory for Geoenergies is part construction site, part mechanics garage, and part excavation.



Inside the six-by-three-metre cavern – once part of a railway tunnel – a team of researchers specialising in geology and seismology conduct their work wearing hard hats. This is one of the world's leading research facilities in deep geothermal, a renewable energy source that has the potential to upend our reliance on unsustainable and fossil fuels, and may even help with phasing out nuclear.

"I'm sorry it's a bit of a mess today," says lab manager Marian Hertrich, referring to the motors, laptops, giant spools of fibre-optic cables and drill rig that compete for space in the tight quarters. For a man who spends half his life underground, the German geophysicist is suspiciously tanned.

The lab is situated in an abandoned ventilation arm of the Furka Base Tunnel, which is operated by Swiss railway company Matterhorn Gotthard Bahn, connecting the cantons of Valais and Uri. One end disappears into inky blackness, the other to dimly lit railway tracks, where a team dressed in high-vis overalls are ferried in and out to the south-eastern exit of the five-kilometre-long tunnel on a custom-made trike that affixes to the steel rails. Half the adventure is in getting here. The 40-minute walk in is unnerving, with pools of water underfoot and 16,000 volts running in via the cables overhead. On one part of the tunnel wall you can see where, millions of years ago, a mass of molten magma forced its way through a long rupture – a feature marked by a vertical join between two different rock types. One is Rotondo granite – an immense physical barrier which engineers tunnelled under 50 years previously.

"One reason I chose Bedretto as a tunnel is because it has two exits. I don't want a landslide or an avalanche," says Domenico Giardini, professor of seismology and geodynamics at Swiss university ETH Zürich. "If you want to operate a lab under a mountain for 20 years, it needs to be very safe."

A leading authority on deep geothermal energy, Giardini is the brains behind the pioneering underground rock lab, a collaboration between ETH Zürich and the Werner Siemens Foundation, which provides funding for research projects and is the lab's main financial backer. Inaugurated in May 2019, the lab's mission is to explore the potential of geothermal – a renewable energy source buried deep underground.

By inducing tiny artificial tremors known as micro-quakes and then observing how the underground rock

behaves, Giardini and his team hope to finally understand how to make this overlooked and underutilised renewable source of potential clean energy safe and economically viable in the future.

Described as "the Sun beneath our feet", geothermal (a portmanteau of "earth" and "heat" in Greek) is the residual warmth from molten rocks formed within the Earth's interior billions of years ago. Geothermal energy converts this natural heat percolating deep underground into electricity.

Humans have been tapping into geothermal for thousands of years. Ancient Romans harnessed its powers to heat rooms, bathe and even treat skin diseases in Pompeii. Today, the world's oldest geothermal field, Larderello in Tuscany, still generates ten per cent of the total global geothermal energy supply. The World Energy Council estimates that as a source of power, it has the potential to deliver more than eight per cent of the world's electricity needs. Yet it still accounts for a minuscule 0.3 per cent of globally installed renewable energy capacity, mainly due to seismic risk, the lengthy experimental phase and high start-up costs.

On paper, geothermal sounds too good to be true. Our planet will likely supply heat from within for millions of years to come, and, unlike solar and wind, geothermal doesn't rely on the fickle climate above ground. "If you go one metre down, the rock doesn't know if it's night or day," Giardini says. "Three metres down, the rock doesn't know if it's winter or summer. It doesn't know anything at all because the rock is so efficient at retaining heat."

Geothermal pulled clean energy innovator Iceland out of economic ruin in the 70s by enabling the country to transition from expensive fossil fuel imports to generating 80 per cent of its own electricity and heating. Today, nine out of ten Icelanders live in geothermally heated homes. But Switzerland isn't a volcanic island where scalding hot water can be drawn just a few hundred metres under your feet. In this landlocked, mountainous country, you need to go 3,000 metres-plus – into hard crystalline rock – to reach temperatures of 100°C.



Left: Marian Hertrich, the lab manager of the Bedretto Underground Laboratory for Geoenergies. Below: the entrance to the Bedretto ventilation tunnel, which leads to the cavern now being used by Hertrich and his team



An enhanced geothermal system (EGS), also known as “hot rocks”, is a process designed for less tectonically active regions such as Switzerland. EGS works by injecting water at high pressure into the Earth’s bedrock, where it absorbs the heat from these “hot rocks”, before being recovered via a shaft bored into the ground. Unlike conventional geothermal systems that harvest heat from porous rocks where hot water naturally flows, EGS has to artificially engineer permeability. The technology was first trialled in New Mexico half a century ago, but has only seen incremental gains in this time. EGS could, in theory, unlock untold reserves of heat from almost anywhere. The International Energy Agency (IEA) estimates that the heat flowing into the upper kilometres of the Earth’s crust amounts to more than two million times the world’s annual energy consumption.

In 2050, every one of Switzerland’s 26 cantons is poised to run on partial geothermal power, with a view to phase out nuclear, which currently supplies 40 per cent of Switzerland’s energy needs,

and replace fossil fuels. According to the Swiss Federal Office of Energy, which invested £47 million into geothermal projects in 2020, Switzerland already has the highest concentration of heat pumps per square kilometre in the world, supporting almost 15 per cent of Swiss heating systems in homes and offices. However, heat pumps fall under the umbrella of “shallow” geothermal, which harnesses the warmth emanating from the Earth’s crust between 1.5 and 400 metres below. “Deep” geothermal such as EGS, on the other hand, require drilling to depths of up to 5,000 metres.

In this respect, Switzerland may have an unexpected ace up its sleeve – a vast network of underground tunnels. Built by the armed forces as part of the country’s now retired “Swiss Reduit”



defence system, these alpine fortresses are how Switzerland came to bunker itself into the Alps during World War II. In the last few decades, some of the tunnels have been repurposed for high-security storage – outfitted with bullet-proof vaults in which to deposit gold. But the former military bunkers of the Saint-Gotthard Massif mountain range could also serve as portals to a reliable green energy source.

“Underground labs are expensive, because you need to reach them first,” Giardini says. “That’s where having a ready-made tunnel comes in handy.”

Below: cables snake out of boreholes lined with sensors including pore-pressure, fibre-optic and geophones. Right: underground lab scientists work at a borehole that has been drilled at a 45° angle. This allows access to reservoirs of heated water in the cracked rock far below

There’s one major issue with enhanced geothermal systems: earthquakes. The reputation of geothermal power in Switzerland nosedived in 2006, when the city of Basel was rocked by a 3.4-magnitude earthquake triggered by a pilot project. The uncontrolled tremors were judged to have been a result of Geopower Basel pumping pressurised water up to 4.8km underground. While

there were no serious injuries, the quake shattered roof tiles and rendered cracks in buildings and medieval cathedrals in the city, which sits atop a 125-metre-long active fault (a natural earthquake along the fault in the 14th century flattened the city). The operation was swiftly halted, but in the months that followed, sensors recorded thousands of tiny quakes, which were attributed to the deep geothermal project.

The ground trembled again in 2013, this time 200 kilometres east in the city of St. Gallen, during the drilling for a £135 million-funded EGS project that was shelved shortly after.

The Bedretto Laboratory is exploring techniques to try to make the most of deep geothermal without running the risk of another incident. In November 2020, Bedretto began its first full-scale stimulations, which are known to cause tiny levels of shaking (imperceptible without scientific measuring equipment), or “micro-earthquakes”. A stimulation involves creating a network of cracks in the granite by injecting a few tens of cubic metres of



cold water through it. “When you run an experiment, there are maybe 10,000 small quakes, and you need to locate them in real time,” Giardini says.

The location of these experiments is a small pool excavated at the tunnel’s base, which could easily be mistaken for an underground spring. Cables sprout from two 22-centimetre boreholes drilled 300 metres deep at 45° angles into the granite to access reservoirs. These aren’t the spectacular alpine kind that Ticino is known for, but heated underground ones, created artificially by pumping water at high pressure to prise open cracks (known as fractures) into less permeable areas of rock. These cracks act as a radiator, transferring heat in the rock to the water, which, in the case of geothermal plants, is then piped back up to the surface of the Earth, where it evaporates into steam. The steam rotates the blades of a turbine, in turn activating a generator which creates electricity that can be directly transported via conventional power lines. A renewable in the most literal sense, the condensed steam can even be pumped back underground, restarting the cycle of heating.

Lining the boreholes are different types of sensor, including acoustic and pore-pressure (which measure the force of the water as it runs through the cracks), as well as fibre-optic cables and geophones (which detect ground velocity produced by seismic waves). Together, these monitor and record vibrations in the granite as the water is injected into sections of the borehole. This data helps to map out the rock’s permeability by revealing the fracture’s size, characteristics, quantity, direction and stress capabilities under different water pressures. Knowing to what extent the granite can be made “artificially permeable” will inform whether a reservoir that stands up to geothermal extraction can actually be made.

For now, the lab is pumping in liquid at 17 degrees Celsius, with hot water experiments scheduled for later in the year, in conjunction with Bedretto tunnel’s second lab opening. Eventually, sufficient fractures will have been made in the rock to connect the two boreholes, creating a reservoir of heated underground fluid, where the full EGS process can be tested and studied.

By using long boreholes to create

underground reservoirs at the 100 metre scale, Bedretto is conducting experiments under conditions that more closely mimic those of a geothermal power plant. And by dividing the boreholes into different sections, the team is able to conduct multi-stage stimulations, which should, in theory, limit the seismic risk by giving the researchers more control.

“I think the biggest event so far was -3.2 or something,” says Ben Dyer, a seismologist for Geo-Energie Suisse, one of Bedretto’s partners. To put these numbers in context, magnitudes need to reach around 2.5 before they’re perceptible above ground. “I think to be honest, when you get beyond zero through the rock, we’d hear the cracks [in the lab],” says Dyer. Anything less than that is considered a micro-quake. These are scrutinised nonetheless, displayed in real time as a series of squiggly lines or “seismic waves” on an ECG-like monitor.

Erring on the side of caution, Bedretto has installed five seismographs (devices that measure earthquakes in the Earth) in the tunnel’s interior: one at the entrance, one at the end, and three directly in the lab, as well as three new seismographs at the Furka, Nufenen and Gotthard Alpine passes. ETH’s own seismic risk study concluded there would be a one in ten million chance of a magnitude 2-2.5 earthquake being triggered. But, as Giardini plainly notes, “Small risk doesn’t mean zero risk. It’s difficult to introduce any new technology unless you really prove there is no risk.”

The line between inducing artificial tremors to yield sufficient data, and triggering an earthquake that could be powerful enough to derail the entire project, is a fine one. Research at Bedretto has the potential to drive down the costs and risks associated with the discovery of geothermal heat. But by the same token, any negative incidents could give pause to investors in similar projects. “The best thing that could happen to geothermal in Switzerland would be to have one project that finally works, with no snags,” says Elmar Grosse Ruse, a climate expert from World Wildlife Fund (WWF) Switzerland.

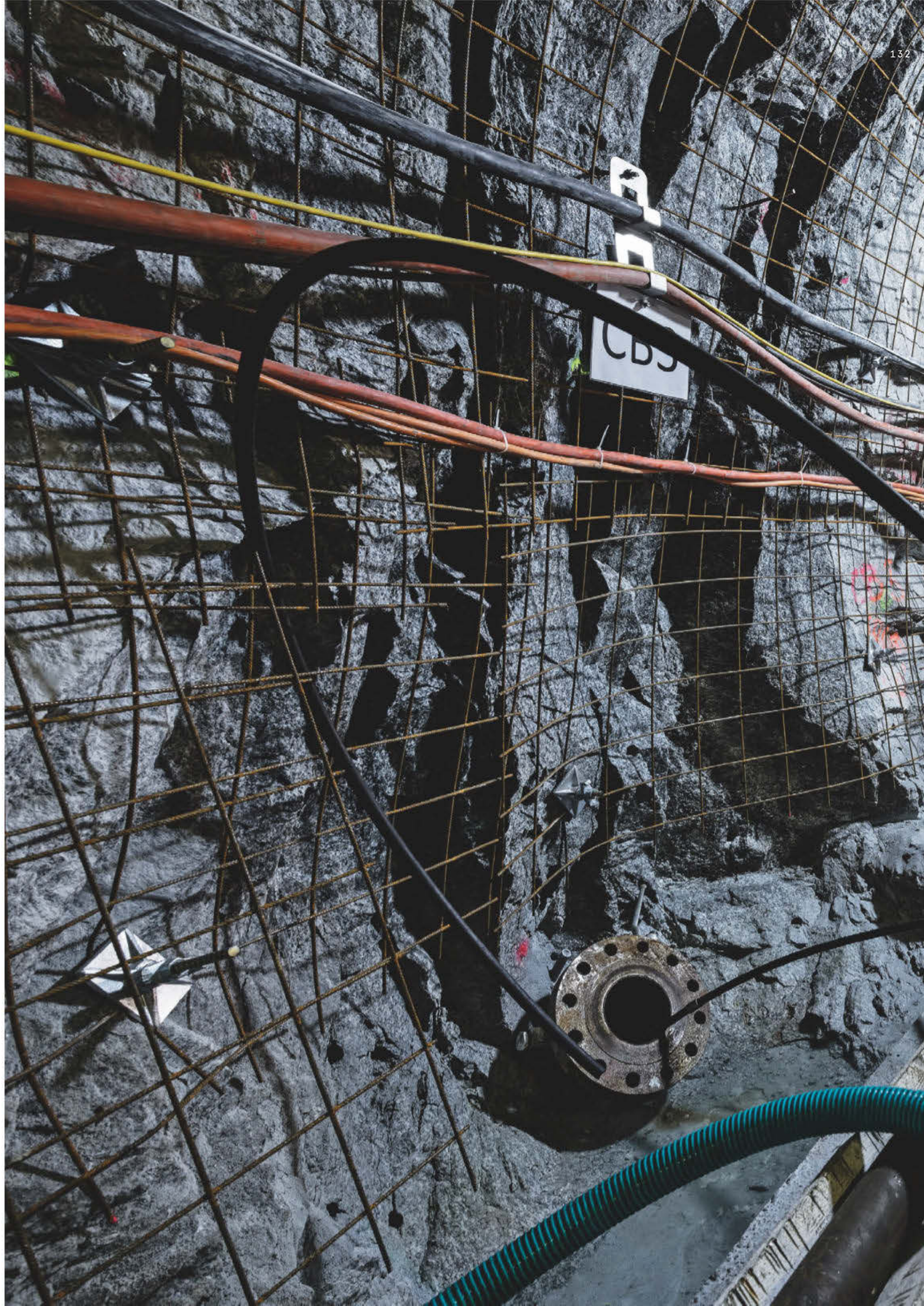
Hazel Gibson, former post-doctoral researcher at Plymouth University’s Sustainable Earth Institute, has spent two years finding out how to manage public trust in geothermal technology. “In the case of deep geothermal, not only is this space invisible, it’s also completely alien to most people who don’t think about what’s going on under their feet until they need



to,” she says. “It’s unfamiliar technology, and unfamiliar risks are often judged to be more risky than familiar ones.” She adds that the language associated with geothermal – “fracture”, “fault”, “earthquake”, “seismic” – can be daunting.

Meanwhile, for the residents of Bedretto Valley, avalanches are a far more tangible threat than a minor quake triggered by scientists. Bookended to the west by Nufenen, Switzerland’s highest paved alpine pass, and to the east by the town of Airolo in the southern foothills of the Gotthard Pass, the valley is streaked with steep gullies and meandering rivers, where a quartet of villages are bunkered into the hillside.

Scarcely 500 metres from the Bedretto tunnel’s south-east entrance is the chocolate-box hamlet of Ronco (home to just four permanent residents) and 3km down the road, the 13th century hamlet of Villa – which went as far as to remodel its church bell tower to serve as an avalanche breaker. The days of being evacuated on mule-drawn sleighs may be long gone, but Agnese Leonardi lives here with her two teenage sons and husband Marco. They run the nearby Cioss Prato ski lift and a grotto at its base, which is ornamented with





'It's the failures that usually end up in the news. If you have an earthquake, everyone will know'

15-million-year-old crystals, dredged from the depths of the Gotthard by Agnese's father-in-law and crystal hunter, Gilberto. The family know more than most about the unusual properties of the ground beneath their feet, and yet draw a blank at the mention of the nearby Bedretto Laboratory.

The lab says it's been fully transparent about its activities. At its unveiling in May 2019, more than 300 people from the public (including Bedretto Valley's residents) were invited to visit and chat with the researchers. But with Covid-19 disrupting these tours for the best part of 2020, some residents remain unaware.

"The idea that if scientists provide more information then people will automatically feel more comfortable with a scientific idea is not really true," says Hazel Gibson. "What is more important to help people connect to new scientific ideas is the way we communicate." Social solutions, she says, are just as important as technical ones.

Getting Bedretto's community of 106 people onside is one thing, but convincing a city with a population of 600,000, like Geneva, is another. Humans have an inherent fear of earthquakes. "All of our system is based on the fact that everything below us is stable, otherwise we feel sick immediately," Giardini says. "It's not so different from the fear of sharks. You are on the beach, and say there is a dolphin, everyone comes to take a picture. You say there is a shark and people fly out of the water, even if the two are equally dangerous."

But despite incidents like the Basel earthquake, "geothermal still has an

image of a clean, silent source of energy in Switzerland," Grosse Ruse says.

The environmental community is also generally receptive to geothermal, despite controversy over some projects imperilling freshwater resources, similar to New Mexico's Lightning Dock plant. "Although engineered geothermal does involve some processes that are similar to fracking, they don't require the addition of possibly hazardous chemicals below ground," explains energy expert and author Chris Goodall.

Currently, geothermal is a bit-player in Switzerland's energy production, alongside wind and solar, which account for 8.5 per cent of total energy consumption, and hydropower, which generates 60 per cent of the country's domestic electricity production.

Often referred to as the water tower of Europe, Switzerland is primed for hydropower, thanks to its mountainous

electricity. When it comes to surface footprint, geothermal plants also take up considerably less space than solar or wind farms, and their underground reservoirs serve a dual purpose – hoarding both energy and the greenhouse gas carbon dioxide.

But despite the list of pros, many geothermal projects never make it past the exploratory phase, which only pays off if sufficiently hot and abundant water reservoirs are uncovered. Australia's flagship geothermal developer, Geodynamics Limited, learned this lesson the hard (and expensive) way. It invested £110m drilling five wells, one kilometre deep into South Australia's Cooper Basin that are now plugged with concrete after being found to be economically unviable.

Even at Bedretto's modest 1,500m depths, the early engineering challenges – before stress levels in the rock were even measured – were hairy, lab manager



terrain and high levels of annual rainfall. But Grosse Ruse says there is a need for something new. "There's not much potential left for 'more' hydropower in Switzerland. Those projects have such a high detriment on the rivers and biodiversity," he says. "And with hydropower, we know that even if receding glaciers continue at the pace they are at the moment, the capacity would still be very limited in the next two decades."

Different countries may have different reasons to opt for geothermal above other renewables. "It is possible that geothermal may never become cost competitive with solar and wind in somewhere like the UK," Goodall says. "Whereas, say, in Kenya, it is a real competitor because temperatures close to the surface are so much higher." Giraffes and geothermal happily coexist in Hell's Gate National Park in the Great Rift Valley, where steam generates close to half of the east African country's

Hertrich recalls. "We drilled and drilled (into the rock) and metre by metre it was completely dry," he says of their preliminary excavations. "We left it open for two weeks and not a single drop of water came out. I was really concerned. Then all of a sudden we drilled through a fracture zone, and the fun began."

One knowledge gap that still needs to be filled is where the best sites are for developing large-scale EGS. Production-scale deep drilling remains the ultimate test of a geothermal prospect. "The problem was getting a drill to fit in here," Hertrich says. In the end, the team commissioned a Swedish company

to manufacture a drill rig from scratch, one that was tailor-made to the tunnel's exact specifications. While he won't disclose the cost, the geophysicist does remark that hiring a geothermal drilling rig can set companies back £100,000 a day. The vast majority of EGS projects are stalled by the capital costs; generating backing for the lab was swift by industry standards. Bedretto's main sponsor, the Werner Siemens Foundation, invested £3.3 million in the lab infrastructure alone, while a raft of other investors, including the Federal Office of Energy and European Research Council, contributed a further £6.5 million. A significant cost saving has been rent-free-premises, thanks to the Matterhorn Gotthard Bahn, which granted ETH Zürich unlimited use of Bedretto tunnel for the next decade.

Another of the Bedretto lab's main challenges (and which is shared by

"We need to transfer continuously in order to bring this data back from this remote mountain area to Zürich, without re-cabling the landscape," Kästli says.



The most important consideration to undertake, if deep geothermal is to become more mainstream, is a greater understanding of the geology. Hertrich and his team have committed to learning the behaviour of Rotondo granite inside out, under every possible rock stress scenario. "Usually you drill in the dark. You drill, you install (boreholes) and then you stimulate," he says. Not at Bedretto. Propped up against the tunnel's exposed walls are dynamite-like crates containing ten-centimetre-diameter cores of granite excavated from experimental boreholes in May 2019. These salt-and-pepper samples have

Left: these ten-centimetre-diameter cores of granite were excavated in 2019. They can be analysed to help identify where and how to create rock fractures for Bedretto's heat reservoirs



other deep geothermal energy projects) is a technological one: namely data acquisition and real-time analytics. "Currently, the independent software for analysing hundreds of data streams of seismic data, sampled with as high frequencies as 1MHz, in real time, doesn't exist," Bedretto's Head of IT, Philipp Kästli, says. To deal with this, the Bedretto team has written its own.

"This isn't the kind of data you can put on a stick," Giardini says, referring to the 12TB of uncompressed data generated by the lab on an average day. "We are metres away from the borehole, so what we see is extremely high frequency. This frequency would usually be taken away by the friction inside the Earth so you wouldn't see it." This seismic data is read and transported back to ETH's headquarters in Zürich in real time – the only way to send it, since the cumulative amount would simply overwhelm the system.

been scrutinised for every vein, pore, joint and fracture for nine months, by some of the industry's keenest eyes. The drilled cores are being used to learn where and how to create fractures for Bedretto's heat reservoirs, so the team can manipulate the rock's behaviour in the way they want to. Such detailed levels of geological, geophysical and geochemical surveillance is nudging geothermal into new territory.

In reality, it's still a long and expensive process to get from lab to plant. The Bedretto Laboratory has no intention of building a commercial geothermal plant on site, although next summer it hopes to extricate hot water from the experimental research reservoir for heating and electricity generation (depending on the temperature), in conjunction with a regional electricity provider.

Whether or not a world in the throes of a climate and energy crisis can afford to wait for geothermal to commer-

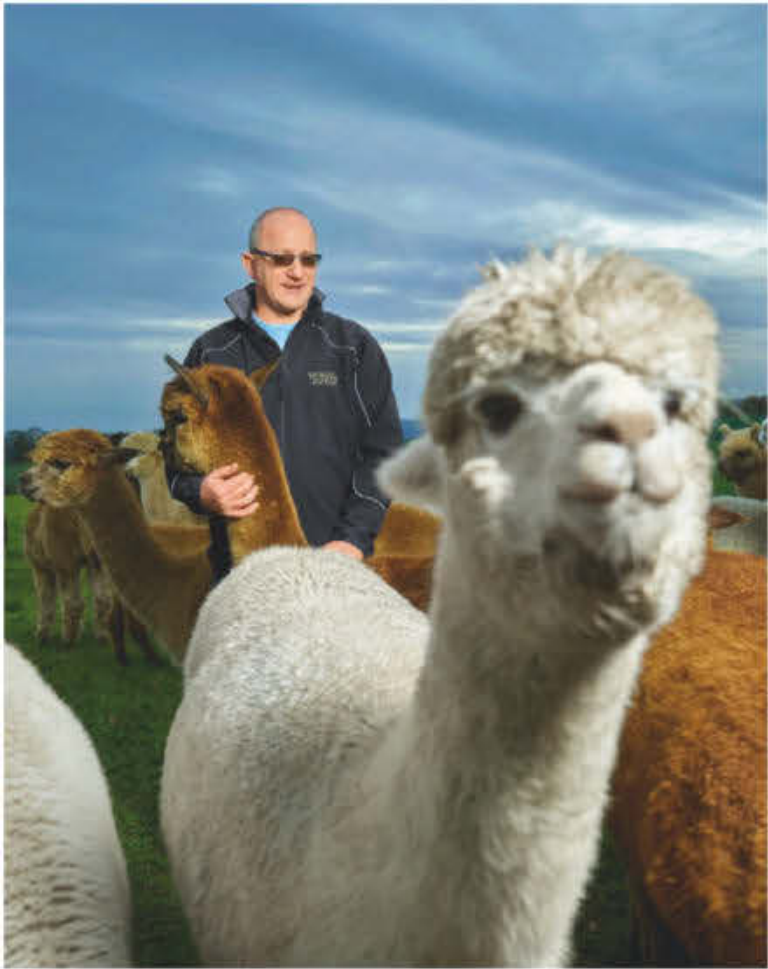
cially mature remains to be seen. While shallow geothermal covers 1.3 per cent of Switzerland's heating needs at the moment, that's not nearly enough to fill the 40 per cent energy shortfall that nuclear will leave behind in 2050. The Bedretto Laboratory is slated to run until 2024, so electricity isn't going to be generated overnight, and presently, there are no operational deep geothermal plants in Switzerland. The planning and construction of a typical heat-and-power geothermal plant can take up to six years and the outlay for one can be in the region of £50 million.

But the patience and investment could pay off, especially if companies can identify areas where drilling is more likely to hit a rich patch of geothermal. This is something Bedretto's research will directly inform in other regions of Switzerland, as well as Scandinavia, which shares a similar rock geology.

If the hard data retrieved from in-situ stimulations such as Bedretto can bolster public and investor confidence, then it has the capacity to spark a renewable energy revolution, starting with fast-tracking the deployment of geothermal power in its home country.

Domenico Giardini is very aware that success or failure here could well determine the fate of deep geothermal energy in Switzerland, and possibly beyond. "The failures are usually the ones that end up in the newspaper," he says. "If you have a 2.5-magnitude earthquake, everyone will know." ■

Sarah Freeman is a journalist covering the environment, culture and travel



ON THE ROAD

“This shoot was the first time that I’d left London since the start of the plague, and I’d never have thought that I’d be so excited at the prospect of a road trip to Newcastle, Leeds and deepest Wales,” says photographer Dan Burn-Forti of his shoot for Work Smarter. “The trip took in getting up close and personal with 300 alpacas, some off-road excitement across the moors of Northumberland, a bit of tasty vegan ice cream in Leeds, and finished with us standing barefoot in the sea on one of the most beautiful beaches I’ve ever seen, Newborough beach in Anglesey. I think it reminded me that Britain is in fact marvellous.”

Colophon



OPENING UP THE GATES

“There’s a video of comedian Gary Gulman doing stand-up about the wealth difference between Bill Gates and Donald Trump,” says John Keatley, who photographed Gates for our cover. “I asked Bill if he knew it. He did – and loved it. It’s rare that a person is the subject of a comedian, but not the butt of the joke. Bill and I tossed funny lines from the routine back and forth, and I got some wonderful moments of unguarded emotion.”

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HELP SAVE THE LAPTOP

Most of the world's laptops and other gadgets are made in China's Yangtze River basin. The region is home to iconic species – think snow leopard and giant panda – and 480 million people. The natural resources that support all this life, as well as 40% of China's GDP, are stretched beyond their capacity. WWF worked with the Chinese government to create a sustainable development model that can support people and nature. Together, we're looking after our shared home. panda.org/togetherpossible



THE WIRED MATRIX



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YVETTE MICHELE

Artist Yvette Michele, is an abstract artist that creates inspiring and one of a kind artworks that are both rich in colour and in depth. Her latest body of work Perspectives is an artistic abstract MashUp and an intertwining of her path of self discovery through technology. This piece titled "I've got Apple in my eyes" is created from a generation 1 iPad. To see more of her work visit: yvettemichele.com IG: [@ArtistYvetteMichele](https://www.instagram.com/ArtistYvetteMichele)



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WIRED
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FEATURE


STEPHANIE DILLON
Art and the unexpected. Stephanie Dillon is a multi-disciplinary artist based in Minnesota. Her vibrant works are made with found materials, paints, chalks and recycled canvases. She believes that old is still beautiful, what we have is enough, and art is everywhere. Stephanie has collaborated with her friend Christian Schauf, the CEO of Uncharted Supply CO, crafting art using flannel shirts and canvases sourced from landfills to create one-of-kind pieces to wear and put on your walls. This flannel has Stephanie's signature Bull on the back. The canvas was found in Northern Minnesota. She used acrylic and spray paint to create this one-of-a-kind art on duck cloth. It is 48 inches by 72 inches. Sometimes finding yourself in uncharted territory is good. Check out what they both do at stephaniedillonart.com, [@stephaniedillonart](https://www.instagram.com/stephaniedillonart) and unchartedsupplyco.com, [@citizen-t](https://www.instagram.com/citizen-t) and [@citizentee](https://www.instagram.com/citizentee)





5.2 MILLION

CCTV cameras, including video doorbells, estimated to be installed across the UK, according to CCTV.co.uk



1 IN 3

The proportion of people who end up in their dream job, according to a survey of 2,000 Americans



40

Extra days it took the UK to bring its coronavirus R number below 1 during the first wave – only Sweden managed worse

37%

Percentage of quotes attributed to female experts in health-related news coverage of the coronavirus, compared to the 63 per cent of quotes attributed to male experts

ONE PER CENT

Percentage of farming companies worldwide accounting for 70 per cent of the world's crop fields, ranches and orchards, according to the International Land Coalition

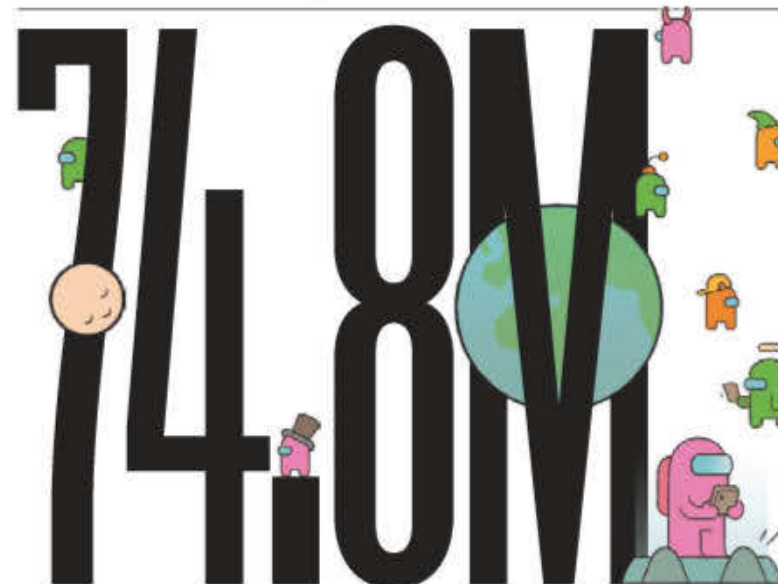
£17,000

Average monthly pay for interns in the consulting sector, making it the most lucrative sector to have an internship



20%

Percentage of Covid-19 patients who, reports an Oxford University study, received a psychiatric diagnosis within 3 months



74.8M

Worldwide downloads of murder-in-space multiplayer *Among Us* in October 2020. It was the year's most-downloaded game

1.8 MILLION

Downloads of *Among Us* just 12 months earlier in October 2019, according to data from the analytics firm Sensor Tower

30% / 27%

Proportion of game developers creating games for the Nintendo Switch, making it the rarest console to develop for, according to recruiters TechNET. Since 2017, nearly 70 million Switches and Switch Lites have been sold worldwide

Proportion of video game developers which create games for the PlayStation, making it the most common console to develop for



£750M

Amount spent by Netflix on UK shows and movies in 2020, up 50 per cent from the year before. From February 2021, the basic UK subscription will rise from £8.99 per month to £9.99

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Vicki



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DEEPSEA UNDER THE POLE GHISLAIN BARDOUT

PERPETUAL PLANET

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